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ON THE DEVELOPMENT AND
DISTRIBUTION OF THE YOUNG
STAGES OF KRILL (*EUPHAUSIA*
SUPERBA)

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(Text-figs. 1-76)

INTRODUCTION

THIS report deals with the development of *Euphausia superba* during the period covered by the first fifteen months of its growth. The distribution of this young euphausian with reference to locality of occurrence, time of occurrence and vertical position is also discussed. It has been possible to come to certain conclusions regarding the life history of the animal, but it is felt that there are many points mentioned upon which more research will be required in order to understand their proper significance. It is hoped, however, that the results set down here will be useful in future analyses of *E. superba* material, especially in connection with the very large collections made by the vessels of the Discovery Committee, and that in this way they may help in the final elucidation of the biology of this animal which is such an important constituent of the antarctic fauna.

In a report to the Discovery Committee in 1930, Dr J. F. G. Wheeler demonstrated that there is a two-year developmental period in *E. superba* as opposed to a one-year period in other euphausians whose life history is known. He measured krill from the stomachs of whales throughout a whaling season, and from the analyses of length frequencies was able to distinguish the two-year groups. Dr Johan T. Ruud in 1932 gave the first published account of this phenomenon.

SOURCES OF MATERIAL

The stations mentioned below, from which plankton samples were examined, are nearly all located in the Falkland Islands sector of the Antarctic. The area round South Georgia was concentrated upon in the earlier stages of the investigations, for at that time ice-edge whale fishing was in its infancy and South Georgia was one of the chief centres of the industry. In addition to observations in the South Georgia area many were made in the Bransfield Strait and on lines of stations in the Scotia Sea. It is perhaps unfortunate that the main source of the data presented is thus in a portion of the Antarctic where hydrographic and bathymetric conditions are so very highly specialized. The great ridge of the Scotia Arc, the proximity of Graham Land to the southern end of South America, and the system of currents associated with the Weddell Sea, all con-

tribute to the production of a complex the like of which is encountered in no other region of the Antarctic.

Apart from the stations in the area of the Dependencies of the Falkland Islands, much valuable material was obtained from a series of ice-edge stations extending from eastwards of Bouvet Island to South Georgia: also from stations in the Bellingshausen Sea and from stations made during the first circumpolar cruise of the R.R.S. 'Discovery II' in 1931. Respecting the last series of stations I am indebted to Mr D. Dilwyn John, who was senior scientific officer on the ship at that time, for examining the plankton samples and sending me the young euphausians. I have also drawn very greatly on the information contained in his reports to the Discovery Committee relating to this circumpolar cruise.

A list of the samples in which eggs or young *E. superba* were obtained is given in Table I. The 70-cm. nets yielded the main supply of younger developmental stages, the 1-m. oblique and horizontal nets older larvae and adolescents. The 1-m. oblique and horizontal hauls of the circumpolar cruise were at stations most of which were made during the southern winter. Both in time distribution and in the development of the *E. superba* recorded, the results of the circumpolar cruise form a convenient link between the main body of 70-cm. net results and those of the 1-m. nets.

The plankton samples of the circumpolar cruise were examined by John and only the picked out krill was dealt with by the writer. John's search for *E. superba* covered all stations made between the Antarctic convergence and the ice-edge.

The positions of all stations from which samples were examined are marked on the maps showing distribution, and indication is provided of the presence or absence of krill.

METHODS

A full description of the plankton nets used in obtaining the samples is given in Vol. I of the *Discovery Reports* (Kemp, Hardy and Mackintosh, 1929) and it is therefore unnecessary to recapitulate it here. The whole catch was examined in the small samples and a portion of the whole was used when very large amounts of plankton were taken. In the search for eggs, Nauplii and Metanauplii the macroplankton was picked out and the residue inspected under a binocular microscope. The Calyptopis and Furcilia stages are sufficiently distinctive to enable them to be identified by eye alone. Drawings of appendages were made from unstained material with the aid of a camera lucida.

For the measurement of the larvae two scales were used of which the smaller, having 62 divisions to 1 mm., was employed for eggs and small larvae and the larger, having 24 divisions to 1 mm., for more advanced stages of development. In analyses where actual length in millimetres is not important, results have been classified primarily according to the original units of measurement. The corresponding dimensions in millimetres have been added.

In order to measure the larvae as speedily as possible a shallow trough, having the two long sides at an acute angle, was constructed by cementing strips of glass on a

Table I. *Stations at which Euphausia superba was taken*

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
R.R.S. 'Discovery'						
1927						
161	57° 2' 20" S, 46° 43' 30" W	14. ii	N 70 V	100-50	0905	—
				250-100	—	1100
167	60° 50' 30" S, 46° 15' W	20. ii	N 70 V	250-100	1045	1130
169	60° 48' 50" S, 51° 00' 20" W	22. ii	N 70 V	500-250	0905	—
				750-500	—	1210
171	62° 07' S, 57° 03' W	25. ii	N 70 V	250-100	0905	1100
187	64° 48' 30" S, 63° 31' 30" W	18. iii	N 70 V	100-50	0945	1020
193	63° 24' S, 61° 33' W	28. iii	N 70 V	500-250	1100	—
				750-500	—	1240
194	62° 57' 30" S, 60° 22' W	28. iii	N 70 V	50-0	2100	—
				100-50		
				250-100		
				500-250	—	2220
196	62° 17' 30" S, 58° 21' W	3. iv	N 70 V	50-0	1055	1240
197	62° 27' S, 58° 11' 30" W	3. iv	N 70 V	50-0	1620	—
				100-50		
				750-500		
				1000-750	—	1805
198	62° 38' S, 58° 04' W	3-4. iv	N 70 V	50-0	2220	—
				100-50		
				750-500		
				1000-750	—	0042
199	62° 49' S, 57° 56' 30" W	4. iv	N 70 V	50-0	0900	—
				250-100		
				500-250		
				700-500	—	1030
200	62° 59' 30" S, 57° 49' W	4. iv	N 70 V	300-250	1445	1545
201	63° 00' 30" S, 59° 06' 30" W	5. iv	N 70 V	50-0	0820	—
				250-100	—	0910
202	62° 48' S, 60° 05' W	5. iv	N 70 V	50-0	1720	—
				500-250	—	1915
203	62° 56' S, 59° 50' W	5-6. iv	N 70 V	50-0	2240	—
				100-50		
				250-100	—	0030
204	63° 05' S, 59° 42' W	6. iv	N 70 V	500-250	0800	—
					—	0907
205	63° 14' S, 59° 34' W	6. iv	N 70 V	225-100	1200	1217
206	63° 26' S, 59° 28' W	6. iv	N 70 V	250-100	1545	1615
209	Port Foster, Deception I., S. Shetlands	14. iv	N 70 V	150-100	0900	0940
R.R.S. 'Discovery II'						
1930						
300	52° 25' 30" S, 37° 14' W	20. i	N 70 V	500-250	1730	2036
302	52° 46' 30" S, 37° 12' W	21. i	N 70 V	250-100	0415	—
				500-250	—	0648
303	53° 00' S, 37° 11' W	21. i	N 70 V	500-250	1048	—
				750-500	—	1250

In the column headed "Net", N 70 is the 70-cm. net, N 100 the 1-m. net, and TYF the 2-m. net with stramin bag. B=hailed obliquely, H=hailed horizontally, V=hailed vertically.

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1930						
304	53° 06' S, 37° 14' W	21. i	N 70 V	500-250	1555	1823
305	53° 17' S, 37° 10' W	21-22. i	N 70 V	100-50	2130	—
				250-100		
				500-250	—	2353
312	53° 39' 45" S, 35° 37' 30" W	24-25. i	N 70 V	220-100	2350	0345
313	53° 32' 30" S, 35° 24' 30" W	25. i	N 70 V	250-100	0530	—
				750-500	—	0720
319	53° 37' S, 38° 39' 30" W to 53° 33' 30" S, 38° 37' W	29-30. i	N 70 V	50-0	2253	—
				100-50		
				250-100		
				1000-750	—	0116
320	53° 10' 30" S, 39° 44' 30" W	30. i	N 70 V	250-100	1610	—
				500-250	—	1806
321	53° 17' S, 39° 31' W	30-31. i	N 70 V	100-50	2119	—
				1000-750	—	2352
323	53° 28' S, 38° 55' W to 53° 29' S, 38° 55' 30" W	31. i	N 70 V	500-250	1105	—
				1000-750	—	1247
324	54° 56' S, 39° 57' W to 54° 56' S, 40° 01' W	1. ii	N 70 V	250-100	0855	—
				500-250	—	1215
332	54° 44' 30" S, 39° 09' W	2-3. ii	N 70 V	250-100	2300	2330
335	55° 33' S, 36° 49' 30" W to 55° 31' 30" S, 36° 49' 30" W	4-5. ii	N 70 V	50-0	2203	0315
337	55° 09' S, 36° 48' W	5. ii	N 70 V	250-100	1223	1440
338	55° 00' 30" S, 36° 46' W	5. ii	N 70 V	225-100	1614	1646
342	55° 47' S, 34° 11' W	7. ii	N 70 V	500-250	1210	1505
343	55° 40' S, 34° 23' W	7. ii	N 70 V	250-100	1724	1850
344	50° 33' S, 34° 35' 30" W to 55° 29' 30" S, 34° 34' W	7-8. ii	N 70 V	100-50	2135	—
					—	2350
345	55° 20' S, 34° 47' 30" W	8. ii	N 70 V	180-100	1155	1257
353	54° 17' 30" S, 35° 06' W	9. ii	N 70 V	250-100	1216	1405
354	54° 15' 30" S, 34° 47' 30" W to 54° 13' 15" S, 34° 46' W	9. ii	N 70 V	500-250	1548	—
					—	1800
356	54° 11' S, 33° 49' W to 54° 08' 45" S, 33° 47' 30" W	10. ii	N 70 V	250-100	0610	—
				500-250	—	0743
357	53° 07' S, 34° 48' W to 53° 07' 30" S, 34° 45' 30" W	10. ii	N 70 V	100-50	1835	—
				250-100	—	2217
358	53° 16' 30" S, 35° 02' 30" W to 53° 17' S, 34° 58' W	11. ii	N 70 V	50-0	0113	—
				100-50	—	0357
360	55° 53' S, 32° 33' W to 55° 50' S, 32° 26' 30" W	24-25. ii	N 70 V	50-0	2020	—
				100-50	—	2330
361	55° 53' 30" S, 30° 46' W to 55° 52' 30" S, 30° 44' W	25. ii	N 70 V	50-0	0909	—
				100-50		
				250-100	—	1220
362	56° 04' S, 29° 15' W to 56° 03' 15" S, 29° 20' W	25. ii	N 70 V	50-0	1835	—
				100-50		
				250-100	—	2146
365	56° 55' S, 27° 02' W to 56° 53' S, 26° 59' W	2. iii	N 70 V	50-0	1305	—
				100-50		
				250-100		
				500-250	—	1505

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1930						
368	Douglas Strait, Southern Thule, S. Sandwich Is., one mile N. of Twitcher Rock	8. iii	N 70 V	50-0 100-50 250-100 500-250	1000 —	— 1050
369	59° 17' 15" S, 26° 57' W	9. iii	N 70 V	50-0 250-100	0855 —	— 1053
372	57° 57' S, 29° 53' W	18-19. iii	N 70 V	50-0 100-50 250-100	2214 —	— 0004
373	58° 00' S, 33° 44' W	19. iii	N 70 V	50-0	1959	2204
374	57° 55' S, 37° 30' W	20. iii	N 70 V	50-0 100-50	1847 —	— 2135
375	57° 47' S, 40° 49' W	21. iii	N 70 V	50-0 500-250	1343 —	— 1624
378	62° 21' 30" S, 60° 36' W	13. iv	N 70 V	50-0 100-50	1142 —	— 1210
383	60° 32' S, 62° 42' W	14. iv	N 70 V	100-50 250-100	0703 —	— 1035
393 A	54° 17' S, 35° 30' W	7. v	N 70 V	150-75	1321	1420
393 D	54° 17' S, 35° 30' W	8. v	N 70 V	300-150	0255	0420
453	54° 05' 30" S, 3° 57' 15" E to 54° 07' S, 4° 03' E	16-17. x	N 70 V N 100 B	50-0 165-0	2040 2353	2341 0014
454	53° 42' S, 4° 42' E	17. x	N 100 B	192-0	2147	2203
455	53° 55' 30" S, 4° 47' E	18. x	N 100 B	116-0	0327	0347
459	55° 09' 15" S, 2° 00' E	19. x	N 100 B	183-0	2110	2130
460	56° 46' S, 0° 41' 45" W	20-21. x	N 100 B	155-0	2049	2109
461 A	56° 44' S, 2° 23' 45" W	21. x	N 100 B	80-0 170-80 270-170 385-270 510-385 650-510	1434 1434 1434 1434 1434	1454 1455 1455½ 1456 1456½
			N 70 V	50-0	1603	—
461 B	56° 44' S, 2° 23' W	21. x	N 100 B	750-500 75-0 160-75 255-160 345-255 440-345 520-440	— 1830 1830 1830 1830 1830 1830	1741 1848 1849 1849½ 1850 1850½ 1851
461 C	56° 44' S, 2° 22' W	21-22. x	N 70 V N 100 B	50-0 95-0 200-95 310-200 420-310 535-420 660-535	1956 2236 2236 2236 2236 2236 2236	2127 2256 2257 2257½ 2258 2258½ 2259
			N 70 V	50-0 250-100	2344 —	— 0130

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1930						
461 D	56° 41' S, 2° 24' W	22. x	N 100 B	85-0 180-85 280-180 385-280 490-385 600-490	0237 0237 0237 0237 0237 0237	0257 0258 0258½ 0259 0259½ 0300
			N 70 V	50-0 100-50	0355 —	— 0516
461 E	56° 41' S, 2° 24' W	22. x	N 100 B	75-0 245-160 330-245 420-330 515-420	0629 0629 0629 0629 0629	0649 0650½ 0651 0651½ 0652
			N 70 V	50-0	0725	0842
461 F	56° 44' S, 2° 22' W	22. x	N 100 B	80-0	1025	1046
			N 70 V	50-0 100-50	1130 —	—
461 G	56° 44' 45" S, 2° 21' 30" W to 56° 44' 30" S, 2° 21' W	22. x	N 100 B	250-100 95-0 315-205 (-0) 700-560 (-315)	— 1429 1429 — 1429	1315 1449 1456½ — 1458
			N 70 V	50-0	1540	1736
462	56° 01' S, 7° 28' W	23. x	N 100 B	90-0	2159	2219
463	55° 42' S, 10° 54' W	24. x	N 100 B	132-0	2042	2102
464	56° 03' S, 12° 18' W	26. x	N 100 H	67(-0)	1028	1048
465	56° 49' S, 14° 02' 15" W	26. x	N 100 B	113-0	2059	2117
466	55° 35' S, 16° 31' 30" W	27. x	N 100 B	79-0	2053	2113
467	54° 39' 30" S, 19° 05' 30" W to 54° 40' 30" S, 18° 58' W	28-29. x	N 100 B	143-0	2039	2059
469	54° 07' 15" S, 22° 01' 45" W	29. x	N 100 B	151-0	2141	2201
470	54° 42' 30" S, 26° 36' 45" W	30. x	N 100 B	91-0	2118	2138
471	54° 57' S, 27° 59' 30" W	31. x- 1. xi	N 70 V N 100 B	50-0 168-0	1750 2356	1937 0016
472	53° 23' S, 30° 29' 30" W	1. xi	N 100 B	111-0	2030	2050
475	53° 30' 15" S, 42° 44' 30" W	12. xi	N 100 B	165-0	1835	1855
477	53° 35' 30" S, 41° 25' 45" W	13. xi	N 70 V	50-0 100-50	0029 —	— 0055
			N 100 B	132-0	0134	0153
480	53° 40' 30" S, 39° 54' W	13. xi	N 100 B	161-0	1827	1849
481	53° 44' 15" S, 39° 29' 30" W	13-14. xi	N 100 B	139-0 375-140	0000 0000	0020 0030
482	53° 46' 45" S, 39° 04' 45" W	14. xi	N 100 B	168-0	0519	0538
483	53° 54' 15" S, 38° 25' 30" W	14. xi	N 70 V	50-0 100-50	1315 —	— 1350
			N 100 B	110-0	1418	1438
484	53° 52' 15" S, 37° 05' 30" W	16. xi	N 70 V	50-0 100-50 150-100	0738 — —	— 0814 0845
			N 100 B	73-0	0825	0845

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1930						
485	53° 37' 15" S, 37° 18' W	16. xi	N 70 V	50-0 180-100	1021 —	— 1055
486	53° 24' 15" S, 37° 29' 45" W	16. xi	N 100 B	133-0	1124	1144
			N 70 V	50-0	1326	1514
			N 100 B	124-0	1603	1623
487	53° 11' 30" S, 37° 41' 45" W	16. xi	N 100 B	375-124 108-0	1603 2210	1637 2230
488	52° 59' 45" S, 37° 48' W	17. xi	N 100 B	111-0 370-111	0052 0052	0112 0120
489	52° 48' 15" S, 38° 04' W	17. xi	N 70 V	50-0	0138	0331
			N 100 B	167-0	0950	1010
				400-167	0950	1020
490	52° 35' S, 38° 13' 30" W	17. xi	N 100 B	140-0	1540	1601
491	52° 22' S, 38° 22' 45" W	17. xi	N 70 V	250-100 500-250	1849 —	— 2050
492	53° 12' 45" S, 37° 04' 15" W	18. xi	N 100 B	164-0	2121	2141
			N 100 B	148-0	1312	1335
			N 100 B	155-0	0135	0155
493	52° 35' 45" S, 35° 26' 15" W	18-19. xi	N 100 B	365-155	0135	0207
494	52° 50' 30" S, 35° 35' 45" W	19. xi	N 100 B	160-0	0826	0846
495	53° 04' 45" S, 35° 43' 45" W	19. xi	N 100 B	186-0	1413	1437
496	53° 17' 45" S, 35° 56' W	19. xi	N 100 B	155-0	2019	2039
498	54° 00' 30" S, 36° 22' W	21. xi	N 100 B	137-0	1450	1510
499	53° 44' 30" S, 36° 16' W	21. xi	N 100 B	155-0	1804	1824
500	53° 30' S, 36° 09' 30" W	21. xi	N 70 V	500-250	2004	2250
502	53° 47' S, 33° 51' 45" W	22. xi	N 100 B	142-0	2308	2328
			N 100 B	132-0	2129	2149
503	53° 53' 45" S, 34° 12' 45" W	23. xi	N 70 V	50-0	0016	0212
504	54° 00' 45" S, 34° 33' 30" W	23. xi	N 100 B	115-0	0316	0336
			N 70 V	1000-750	0604	0740
506	54° 14' S, 35° 15' 30" W	23. xi	N 100 B	161-0	1803	1823
507	54° 19' 30" S, 35° 33' 30" W	23. xi	N 100 B	75-0	2012	2032
508	55° 08' S, 33° 35' W	24. xi	N 100 B	181-0	1440	1500
509	55° 05' 30" S, 34° 01' W	24. xi	N 100 B	112-0	2003	2023
510	4.8 miles N 70° E of Clerke Rocks, S. Georgia	25. xi	N 100 B	149-0	0817	0837
511	54° 58' 15" S, 34° 51' 15" W	25. xi	N 100 B	71-0	1115	1135
512	54° 56' S, 35° 17' W	25. xi	N 100 B	137-0	1410	1430
513	54° 53' 45" S, 35° 42' 30" W	25. xi	N 70 V	50-0	1606	1626
514	55° 51' S, 35° 32' W	26. xi	N 100 B	71-0	1651	1711
			N 100 B	155-0	0540	0600
			N 70 V	50-0	0625	—
516	55° 25' 30" S, 35° 52' 45" W	26. xi		100-50	—	0755
			N 100 B	123-0	1520	1540
517	54° 42' 45" S, 36° 36' 45" W	26. xi	N 70 V	50-0	2123	—
518	54° 58' S, 36° 23' W	27. xi		100-50	—	2154
			N 100 B	102-0	2216	2236
519	55° 13' S, 36° 09' 30" W	27. xi	N 100 B	90-0	0119	0139
520	55° 49' S, 39° 07' 15" W	28. xi	N 100 B	137-0	0531	0551
			N 100 B	155-0	0253	0318
			N 70 V	1000-750	0338	0504

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1930						
521	55° 34' 30" S, 38° 43' W	28. xi	N 100 B	164-0	1200	1220
522	55° 20' 30" S, 38° 19' W	28. xi	N 100 B	95-0	1937	1957
523	55° 08' 45" S, 37° 59' 45" W	29. xi	N 100 B	157-0	0413	0433
525	54° 36' 15" S, 37° 23' 30" W	29. xi	N 100 B	110-0	1533	1553
528	55° 33' S, 30° 15' W	12. xii	N 100 B	173-0	2125	2145
537	61° 07' 30" S, 54° 26' W	19. xii	N 70 V	250-100	0440	—
				500-250		
				750-500		
				1000-750	—	0634
			N 100 B	137-0	0645	0705
538	61° 29' S, 54° 44' 15" W	19. xii	N 70 V	750-500	1003	—
				1000-750	—	1203
539	61° 48' S, 54° 51' 30" W	19. xii	N 70 V	250-100	1445	—
				500-250		
				750-500		
				1000-750	—	1652
540	62° 06' 15" S, 55° 08' 30" W	19. xii	N 70 V	50-0	1926	—
				100-50		
				250-100		
				500-250	—	2010
541	62° 22' S, 55° 23' W	19-20. xii	N 70 V	50-0	2248	—
				100-50		
				250-100	—	2320
542	62° 08' S, 57° 28' 30" W	20. xii	N 70 V	500-250	0700	0845
543	62° 16' S, 57° 20' W	20. xii	N 100 B	178-0	1205	1225
546	62° 46' 15" S, 57° 11' 15" W	20. xii	N 70 V	250-100	1919	—
				500-250	—	2000
547	62° 59' 15" S, 57° 03' W	20. xii	N 100 B	37-0	2316	2336
558	65° 31' S, 67° 07' 45" W	29. xii	N 70 V	100-50	2123	—
				200-100	—	2154
1931						
585	67° 08' 30" S, 70° 15' 30" W	13. i	N 70 V	50-0	0346	0425
618	59° 42' 45" S, 43° 57' 45" W	18-19. ii	N 70 V	50-0	2235	—
				100-50		
				250-100		
				500-250		
				750-500	—	0110
620	59° 12' S, 40° 23' 30" W	19-20. ii	N 70 V	50-0	2229	—
				100-50		
				250-100		
				750-500		
				1000-750	—	2359
622	59° 05' 30" S, 36° 25' W	20-21. ii	N 70 V	50-0	2225	—
				100-50	—	2353
624	58° 34' 45" S, 31° 21' 30" W	21-22. ii	N 70 V	50-0	2235	0007
635	57° 42' 45" S, 50° 06' 15" W	7. iii	N 70 V	50-0	2017	—
				100-50		
				250-100	—	2250

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1931						
636	59° 01' 45" S, 49° 18' 30" W	8. iii	N 70 V	250-100 500-250	0941	—
637	60° 00' 15" S, 49° 28' 15" W	8. iii	N 70 V	750-500	—	1230
				100-50	1907	—
				250-100		
				500-250		
				750-500		
638	61° 00' 30" S, 49° 48' 30" W	9. iii	N 70 V	1000-750	—	2028
				250-100	0537	—
				500-250		
				750-500		
639	61° 57' 45" S, 51° 59' W	9. iii	N 70 V	1000-750	—	0730
				50-0	2107	—
				100-50		
				250-100		
				500-250		
644	61° 20' 30" S, 56° 40' W	11. iii	N 70 V	750-500 100-50	—	2240
646	60° 22' 30" S, 57° 43' W	11. iii	N 70 V	250-100	0700	—
				250-100	—	0732
647	59° 29' 15" S, 58° 39' 45" W	12. iii	N 70 V	500-250	1537	—
				50-0	—	1770
				100-50	0110	—
				250-100		
				500-250		
648	58° 30' 45" S, 59° 41' 15" W	12. iii	N 70 V	750-500		
				1000-750	—	0328
				50-0	1106	—
				100-50		
				250-100		
661	57° 36' S, 29° 54' 30" W to 57° 36' S, 29° 35' W	2. iv	TYF B	500-250	—	1239
				360-0	0136	0226
1932						
852	58° 39' 5" S, 40° 03' 9" E	18. iv	N 100 B	119-0	0429	0449
853	61° 00' 2" S, 43° 11' 1" E	19. iv	N 100 B	119-0	0435	0455
854	63° 30' 2" S, 46° 24' 9" E	20. iv	N 100 B	119-0	0342	0402
				248-94	0255	0330
855	65° 10' 4" S, 48° 43' 7" E	20. iv	N 100 B	125-0	2310	2330
				280-154	2310	2340
861	56° 28' 9" S, 79° 18' 2" E	28. iv	N 100 B	109-0	0019	0039
				254-110	0019	0049
862	55° 33' 8" S, 83° 00' 4" E	28. iv	N 100 B	102-0	2313	2333
				220-98	2313	2343
887	63° 41' 4" S, 130° 07' E	27. v	N 100 B	86-0	2119	2139
				235-115	2119	2149
				120-0	2202	2222
				0-5	2213	2233
			N 100 H			

DISCOVERY REPORTS

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1932						
888	63° 23.2' S, 130° 29.7' E	28. v	N 100 B	98-0 240-90	0655 0655	0715 0725
912	61° 02' S, 158° 26' E	24. vi	N 100 H	0-2	1240	1310
954	62° 18.2' S, 128° 16.2' W	9. ix	N 100 H	0-2	1115	1145
955	62° 17.2' S, 158° 13.2' W	9. ix	N 100 H	0-2	1210	1240
956	62° 12.8' S, 158° 11' W	9. ix	N 100 B	97-0 280-100	1351 1351	1411 1421
957	61° 56.3' S, 155° 49.6' W	10. ix	N 100 H	0-2	1046	1116
959	61° 07' S, 153° 57.2' W	10-11. ix	N 100 H N 100 B	0-5 91-0 240-110	2350 0012 0012	0012 0032 0042
994	66° 45.7' S, 80° 19.8' W	29. x	N 100 H	0-5	2155	2255
995	67° 06.2' S, 79° 55.8' W	30. x	N 70 B	320-120	0342	0412
996	66° 53.8' S, 78° 52.6' W	30. x	N 100 H	0-5	1735	1755
998	66° 40.7' S, 75° 13.7' W	31. x	N 100 H	3-4	1158	1230
999	66° 55.8' S, 73° 51.5' W	31. x	N 70 B N 100 H	151-0 0-5	2207 2207	2227 2237
1000	65° 06.6' S, 71° 39.7' W	1. xi	N 100 B	128-0	1108	1128
1001	64° 53.8' S, 68° 43.9' W	1. xi	N 100 B	95-0 230-66 0-5	2143 2143 2147	2203 2213 2207
1002	64° 23.4' S, 65° 44.5' W	2. xi	N 100 H N 70 B N 100 B	86-0 86-0 86-0	0952 0952 0952	1012 1012 1012
1003	63° 40.7' S, 63° 07.7' W	2. xi	N 70 B N 70 B N 100 B	230-94 115-0 115-0	0952 2050 —	1022 — 2112
R.R.S. 'William Scoresby' 1928						
WS 139	53° 00' S, 49° 50' W	10. ii	N 70 V	500-250	1840	2240
WS 141	53° 32' S, 44° 52' W	13. ii	N 70 V	250-100 500-250	1250 —	— 1543
WS 147	53° 50' S, 35° 50' W	21. ii	N 70 V	250-100	2120	2310
WS 182	55° 30' S, 34° 50' W	8. iii	N 70 V	250-100	0355	0715
WS 197	56° 00' S, 40° 50' W	17. iv	N 70 V	100-50 250-100 500-265 750-500 1000-800	0530 — — — —	— 0915 — — —
WS 198	57° 31' S, 42° 52' W	19. iv	N 70 V	250-100 500-250	1310 —	— 1610
WS 199	58° 10' S, 44° 10' W	20. iv	N 70 V	500-250	1025	1255
WS 200	59° 05' S, 46° 32' W	21. iv	N 70 V	500-250 750-500	1220 —	— 1420
WS 201	59° 57' S, 50° 12' W	22. iv	N 70 V	50-0 100-50 250-100	1847 — —	— — 2255
WS 202	60° 23' S, 52° 52' W	23. iv	N 70 V	500-250 100-50 250-100 500-250	1845 — — —	— — — 2115

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1928						
WS 254	53° 03' S, 46° 58' W	22. viii	N 100 B	91-0	1339	1400
WS 255	53° 23' S, 44° 10' W	22-23. viii	N 70 V	50-0	2335	0310
			N 100 B	96-0	0329	0350
WS 256	53° 42' S, 40° 33' W	23-24. viii	N 100 B	100-0	0150	0211
WS 257	54° 04' S, 36° 18' W	27. viii	N 100 B	84-0	1728	1748
WS 258	53° 56' S, 36° 06' W	27. viii	N 100 B	91-0	2055	2118
WS 259	53° 49' S, 35° 53' 30" W	27-28. viii	N 100 B	103-0	0332	0353
WS 260	53° 42' S, 35° 41' W	28. viii	N 100 B	86-0	0515	0535
WS 261	53° 34' 30" S, 35° 28' 30" W	28. viii	N 100 B	104-0	1031	1051
WS 262	53° 27' S, 35° 17' W	28. viii	N 100 B	85-0	1200	1223
WS 263	53° 20' S, 35° 04' W	28. viii	N 70 V	500-250	1320	1630
			N 100 B	87-0	1710	1730
WS 264	53° 13' 30" S, 34° 51' W	28. viii	N 100 B	97-0	1848	1908
WS 265	52° 40' S, 37° 05' W	29. viii	N 100 B	130-0	1230	1250
WS 266	52° 50' S, 35° 05' W	29. viii	N 70 V	750-500	1420	—
				1000-760	—	1640
			N 100 B	89-0	1713	1733
WS 267	53° 01' S, 37° 05' W	29. viii	N 100 B	79-0	1845	1907
WS 268	53° 11' S, 37° 05' W	29. viii	N 70 V	250-100	2020	2300
			N 100 B	106-0	2321	2341
WS 269	53° 21' S, 37° 05' W	30. viii	N 100 B	100-0	0100	0120
WS 270	53° 31' S, 37° 05' W	30. viii	N 70 V	50-0	0240	0415
			N 100 B	116-0	0500	0520
WS 271	53° 42' S, 37° 05' W	30. viii	N 100 B	91-0	0721	0741
WS 272	53° 52' S, 37° 05' W	30. viii	N 100 B	87-0	0955	1015
WS 273	53° 24' S, 39° 00' W	4. ix	N 100 B	124-0	0635	0655
WS 274	53° 30' S, 38° 47' W	4. ix	N 70 V	250-100	0810	1035
			N 100 B	113-0	1132	1152
WS 275	53° 38' S, 38° 34' W	4. ix	N 70 V	100-0	1305	—
				750-500	—	1535
WS 276	53° 45' S, 38° 22' W	4. ix	N 100 B	104-0	2200	2220
WS 278	54° 23' S, 35° 52' W	12. ix	N 100 B	124-0	1938	1958
WS 279	54° 23' S, 35° 35' W	13. ix	N 100 B	114-0	1818	1838
WS 280	54° 23' S, 35° 18' W	17. ix	N 100 B	92-0	1506	1526
WS 281	54° 23' S, 35° 00' W	17. ix	N 100 B	102-0	1646	1706
WS 282	54° 22' 30" S, 34° 43' W	17. ix	N 70 V	50-0	1820	1919
			N 100 B	137-0	2052	2112
WS 283	54° 22' S, 34° 25' W	17. ix	N 100 B	78-0	2320	2340
WS 284	54° 21' 45" S, 34° 08' W	18. ix	N 70 V	50-0	0625	0732
			N 100 B	100-0	0848	0908
WS 285	54° 21' 30" S, 33° 53' 30" W	18. ix	N 100 B	89-0	1021	1041
WS 286	55° 00' S, 32° 55' W	18. ix	N 70 V	50-0	1835	2050
			N 100 B	100-0	2202	2222
WS 287	54° 54' S, 32° 08' W	19. ix	N 70 V	50-0	0815	1055
			N 100 B	164-0	1150	1220
WS 288	54° 52' S, 32° 19' W	19. ix	N 100 B	102-0	1429	1449
WS 291	54° 53' S, 35° 31' W	2. x	N 100 B	120-0	1227	1247
WS 292	55° 02' S, 35° 16' 40" W	3. x	N 100 B	78-0	1604	1620
WS 293	55° 09' S, 35° 05' W	3. x	N 100 B	64-0	1806	1823
WS 294	55° 17' S, 34° 53' W	3. x	N 100 B	98-0	1951	2011

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1928						
WS 295	55° 23' 40" S, 34° 41' W	3-4. x	N 70 V	50-0	2132	0108
			N 100 B	97-0	0140	0200
WS 296	55° 31' S, 34° 29' W	4. x	N 100 B	110-0	0338	0359
WS 297	55° 34' 05" S, 33° 14' W	4. x	N 70 V	50-0	1020	1245
			N 100 B	111-0	1330	1350
WS 298	55° 27' 30" S, 32° 21' 40" W	5. x	N 100 B	94-0	1008	1028
WS 299	55° 18' 30" S, 32° 05' 20" W	5. x	N 100 B	100-0	1205	1225
WS 300	55° 07' 30" S, 31° 56' 55" W	5. x	N 100 B	100-0	1736	1756
WS 301	55° 00' 05" S, 32° 08' 25" W	5. x	N 100 B	88-0	1913	1937
WS 302	54° 57' 20" S, 31° 49' 35" W	6. x	N 100 B	98-0	0522	0542
WS 303	54° 51' 25" S, 31° 20' 10" W	6. x	N 100 B	109-0	1312	1332
WS 304	54° 54' 40" S, 30° 21' 20" W	6. x	N 100 B	110-0	1843	1908
			N 70 V	50-0	1920	2205
WS 305	54° 44' S, 29° 49' W	7. x	N 100 B	100-0	0945	1005
WS 306	54° 41' 50" S, 30° 49' 35" W	7. x	N 100 B	105-0	1427	1447
WS 307	54° 19' 30" S, 30° 31' 30" W	7. x	N 100 B	120-0	1751	1811
			N 70 V	50-0	1840	2125
WS 308	54° 04' 05" S, 30° 18' W	8. x	N 100 B	97-0	0830	0850
WS 309	53° 58' 50" S, 28° 50' 10" W	8. x	N 100 B	91-0	1610	1630
WS 310	54° 00' S, 28° 38' W	8. x	N 100 B	100-0	1800	1820
			N 70 V	50-0	1835	2055
WS 311	54° 45' S, 35° 11' W	10. x	N 100 B	116-0	1811	1839
WS 323	53° 38' 30" S, 38° 35' 10" W	20-21. xii	N 70 V	500-250	2205	0000
1929						
WS 377	58° 34' S, 44° 47' W	9. ii	N 70 V	100-50	1445	1710
WS 380	60° 22' S, 50° 33' W	12-13. ii	N 70 V	250-100	2115	—
				500-250	—	0015
WS 382	62° 15' 35" S, 58° 18' 30" W	15. ii	N 70 V	400-250	1335	1423
WS 385	62° 32' S, 57° 55' W	16. ii	N 70 V	500-250	0005	0215
WS 394	62° 51' S, 60° 40' W	18. ii	N 70 V	200-100	0759	0830
WS 427	53° 34' S, 40° 10' W	28-29. iv	N 70 V	50-0	2155	—
				100-50	—	2248
WS 464	53° 40' S, 37° 33' W	31. x	N 100 B	135-0	2200	2220
WS 468	55° 52' S, 56° 53' W	9-10. xi	N 100 B	193-0	0055	0115
WS 474	61° 03' S, 56° 42' W	13. xi	N 100 B	100-0	2301	2321
WS 476	62° 16' S, 58° 18' W	14. xi	N 100 B	91-0	2054	2115
WS 477	62° 20' 30" S, 58° 14' W	14-15. xi	N 70 V	1000-500	2150	0140
			N 100 B	140-0	0210	0230
WS 478	62° 24' 30" S, 58° 06' 30" W	15. xi	N 100 B	146-0	1535	1555
WS 480	62° 51' 30" S, 57° 47' 30" W	16. xi	N 70 V	200-100	0430	—
				500-200	—	0714
			N 100 B	100-0	0729	0749
WS 481	62° 59' S, 57° 28' W	16. xi	N 100 B	109-0	1046	1108
WS 482	63° 10' S, 57° 16' 30" W	16. xi	N 100 B	54-0	1325	1336
WS 483	62° 46' 45" S, 59° 37' 30" W	21. xi	N 70 V	500-240	0705	0905
WS 484	62° 54' S, 59° 28' W	21. xi	N 70 V	750-500	1155	—
				950-740	—	1352

Table I (cont.)

Station	Position	Date	Net	Depth m.	Time	
					Shot	Hauled
1929						
WS 485	63° 02' 30" S, 59° 17' W	21. xi	N 70 V	500-250	1635	—
				750-500	—	1755
WS 486	63° 11' 30" S, 59° 13' W	21. xi	N 100 B	164-0	1840	1900
			N 70 V	500-250	2020	—
				700-500	—	2135
WS 487	63° 17' S, 59° 20' W	22. xi	N 100 B	109-0	2215	2235
			N 70 V	500-250	0430	0545
			N 100 B	101-0	0618	0638
WS 488	63° 51' 30" S, 62° 30' W	22. xi	N 100 B	107-0	1755	1815
WS 489	63° 38' S, 62° 32' W	22. xi	N 100 B	97-0	2125	2145
WS 490	63° 24' 30" S, 62° 35' 30" W	22-23. xi	N 100 B	98-0	0010	0030
WS 491	63° 12' S, 62° 26' W	23. xi	N 100 B	96-0	0334	0354
WS 496	67° 14' S, 70° 12' W	30. xii	N 70 V	50-0	0950	—
				100-50	—	1125
			N 100 B	600-250	—	1125
				106-0	1249	1309
1930						
WS 497	67° 05' S, 70° 40' W	1. i	N 100 B	97-0	1344	1404
WS 498	66° 21' S, 69° 01' W	2-3. i	N 100 B	101-0	0132	0152
WS 499	65° 45' S, 67° 18' W	3. i	N 100 B	76-0	0903	0925
WS 501	64° 52' S, 63° 58' W	3. i	N 100 B	109-0	2248	2308
WS 505	70° 10' 30" S, 87° 46' W	4. ii	N 70 V	100-50	1118	—
				250-100	—	1308
WS 508	69° 04' S, 77° 40' W	10. ii	N 100 B	91-0	0204	0224
WS 524	53° 36' S, 43° 00' W	2. iii	N 70 V	500-250	0750	0932
WS 527	57° 30' S, 45° 35' W	30. iii	N 70 V	50-0	0812	—
				100-50	—	1020
				250-100	—	1020
WS 529	56° 05' S, 53° 45' W	2. iv	N 70 V	500-250	0930	—
				750-500	—	1200
1931						
WS 534	54° 17' 30" S, 35° 39' W	22-23. i	N 70 V	50-0	2315	—
				100-50	—	0000
WS 538	57° 03' 30" S, 24° 32' W	26. i	N 100 B	97-0	1335	1355
WS 540	57° 55' S, 21° 21' W	27-28. i	N 70 V	50-0	2245	—
				500-250	—	0230
				750-500	—	2235
WS 542	58° 39' S, 18° 13' W	28. i	N 100 B	77-0	2235	2255
WS 560	56° 27' S, 28° 59' W	9. ii	N 100 B	130-0	2140	2200
WS 570	52° 22' S, 38° 23' W	8. iii	N 70 V	250-0	1700	—
				750-0	—	2015
				250-100	1600	1855
WS 572	53° 11' 30" S, 37° 41' W	24. iii	N 70 V	250-100	1600	1855
WS 573	52° 59' 45" S, 37° 48' W	25. iii	N 70 V	50-0	0127	0350

micro slide. Each larva was placed on the slide with the tail projecting into the angle, and was held up by the sides of the trough so that the total length from tip of rostrum to end of telson could be read quickly. The measurement of adolescents was done directly on a scale marked off in 0.5 mm. divisions.

A difficulty was encountered as a result of the preservation of the specimens. The greater mass of the material was preserved in formalin, but nearly all the samples taken by the 'William Scoresby' were in 70 per cent alcohol. A comparison of specimens preserved in alcohol with others from the same stations preserved in formalin showed that a considerable shrinkage had taken place in the specimens kept in the former fluid.

Table II

Station	Numbers averaged	Average length, mm.		<i>A</i> as percentage of <i>B</i>	Factor for expression of <i>A</i> as <i>B</i>
		(<i>A</i>) Preserved in spirit	(<i>B</i>) Preserved in formalin		
WS 263	94	9.99	10.94	91.4	1.096
WS 282	100	13.23	14.47	91.4	1.094
WS 286	100	11.20	12.47	89.8	1.113
WS 288	100	12.04	12.99	92.7	1.079
WS 296	50	14.75	15.79	93.4	1.070
WS 487	100	15.98	17.28	92.4	1.085

The actual figures are expressed in Table II. In order to make the specimens more nearly comparable as regards length the factor 1.09 was employed and records of length of spirit-preserved larvae were multiplied by it to bring them into line with the rest of the measurements.

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Whilst the work on this paper was in progress Dr Rustad published a paper on "Euphausiacea, with notes on their biogeography and development" (1930), and another "On the Antarctic euphausiids from the Norvegia Expeditions, 1929-30 and 1930-31" (Rustad, 1934). Dr Johan T. Ruud (1932) also published his paper "On the biology of southern Euphausiidae". I wish to make full acknowledgment to both of these authors for the use I have made of their publications, which are constantly referred to here.

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DEVELOPMENT

THE EGG

The eggs found in the plankton were identified as those of *E. superba* by comparison with others shed by gravid females, which from time to time were kept in tanks on board the R.R.S. 'Discovery II'. The appearance of the eggs is sufficiently distinct to enable them to be picked out with comparative ease from the plankton samples. They measure 0.6 mm. in diameter when unpreserved, but after formalin has been used there is a decrease in size; for example the average diameters of two batches of a hundred each from two different catches at St. 540 were respectively 0.56 and 0.59 mm. The average sizes obtained from smaller numbers agree closely with these figures. The eggs are opaque and rather densely granular; in reflected light their milky white appearance helps greatly to distinguish them. There is a thin, transparent, unsculptured membrane investing the contents of the egg, the latter completely filling the egg-shell. The average size of the eggs and the depths at which they are found do not seem to be correlated.

At St. 356, 10. ii. 30, 250–100 m., ninety-five adult *E. superba* were obtained in the 70-cm. net, although none were caught in other nets either vertical or oblique. Most of the females were gravid, with spermatophores inserted in the thelycum. Four gravid females were placed in an aquarium, and on the following day the distension of the cephalothorax had subsided and a number of eggs were found in the water. On dissecting a female many eggs were found floating in a milky fluid which appeared to consist of an emulsion of tiny oil globules. The eggs were of the same size as those in the aquarium, namely 0.6 mm. diameter.

At St. 548, 21. xii. 30, 102–0 m., eighty *E. superba* were taken, among them several gravid females. Two of these females were placed in a vessel containing sea water on the upper bridge of the ship, and on December 23, between 2 and 4 a.m., both shed their eggs. The females did not cast their skins beforehand and one still had the spermatophores *in situ*. On December 29 the female without spermatophores died and the other died on the following day; neither had moulted.

Six gravid females were kept alive from St. 602, 19. i. 31, 110–0 m., and in due course eggs were deposited, but attempts to induce segmentation were unsuccessful. The eggs were divided into batches and subjected to varying degrees of temperature. Some were kept in an aquarium at laboratory temperatures, some in a plunger jar on deck at air temperature, and others in a vessel surrounded by lumps of ice. In all the experiments the water was filtered before the gravid females were placed in it.

Eggs occurred in the plankton showing all stages of development, culminating in the clearly distinguishable form of the 1st Nauplius, this latter completely filling the interior of the egg capsule.

Table III. Occurrence of eggs

Station	Date	Depth m.	Number	Average diameter* mm.	Remarks
356	10. ii. 30	250-100	—	—	Eggs from gravid female
537	19. xii. 30	250-100	2	0.55 (2)	
		500-250	8	0.57 (8)	1 adult in sample
		750-500	27	0.58 (27)	1 adult in sample
		1000-750	11	0.57 (10)	
538	19. xii. 30	750-500	2	0.55 (2)	4 adults in sample and cast skin of adult
		1000-750	8	0.58 (8)	
539	19. xii. 30	250-100	3	0.57 (3)	
		500-250	7	0.59 (7)	
		750-500	6	0.57 (6)	
		1000-750	9	0.58 (9)	
540	19. xii. 30	50-0	4	0.57 (4)	
		100-50	52	0.58 (51)	
		250-100	478	0.56 (100)	
		500-250	2496	0.59 (100)	5 adults in sample
541	19. xii. 30	50-0	1	0.56 (1)	
		100-50	5	0.55 (5)	
		250-100	1	0.56 (1)	
542	20. xii. 30	500-250	1	0.56 (1)	
546	20. xii. 30	500-250	4	0.58 (4)	1 adult picked out
558	29. xii. 30	100-50	1	0.58 (1)	3 other eggs not <i>E. superba</i>
585	13. i. 31	50-0	1	0.60 (1)	
618	18/19. ii. 31	250-100	1	0.58 (1)	
637	8. iii. 31	250-100	1	0.55 (1)	
644	11. iii. 31	100-50	4	0.59 (4)	
		250-100	6	0.59 (6)	
WS 147	21. ii. 28	250-100	1	0.60 (1)	
WS 323	20. xii. 28	500-250	1	0.58 (1)	
WS 377	9. ii. 29	100-50	1	0.56 (1)	At St. WS 376, 750-500 m., 4 adult males, 2 adult and gravid females with spermatophores attached
WS 380	12. ii. 29	250-100	2	0.56 (2)	
		500-250	2	0.61 (2)	
WS 382	15. ii. 29	400-250	2	0.55 (2)	
WS 385	16. ii. 29	500-250	1	0.60 (1)	
WS 394	18. ii. 29	200-100	1	0.60 (1)	
WS 477	14. xi. 29	1000-500	1	0.58 (1)	
WS 480	16. xi. 29	200-100	13	0.57 (12)	
		500-200	70	0.60 (10)	2 females with enlarged ovaries in this sample
WS 483	21. xi. 29	500-250	1	0.56 (1)	
WS 484	21. xi. 29	750-500	1	0.56 (1)	
		950-750	1	0.55 (1)	
WS 485	21. xi. 29	500-250	3	0.54 (3)	
		750-500	2	0.58 (2)	
WS 486	21. xi. 29	500-250	1	0.56 (1)	
		750-500	1	0.52 (1)	
WS 487	22. xi. 29	500-250	1	0.56 (1)	
WS 496	30. xii. 29	100-50	1	0.58 (1)	
		600-250	1	0.61 (1)	Shell broken
WS 505	4. ii. 30	250-100	2	0.56 (2)	

* Number from which the average was taken is shown in brackets.

FIRST NAUPLIUS

As shown in Table IV there are only two records of free-swimming 1st Nauplii in the material examined, but at some of the stations where eggs were found, notably at St. 537, many of the eggs contained well-developed naupliar forms. A Nauplius measuring 0.62 mm. in length (Fig. 1*a*) was dissected from an egg, the interior of which it completely occupied. This differs somewhat from Ruud's description (1932, pp. 47, 49, fig. 11), in which the Nauplius in the egg is stated to be 0.51 mm. long and does not completely occupy the space within the egg-shell.

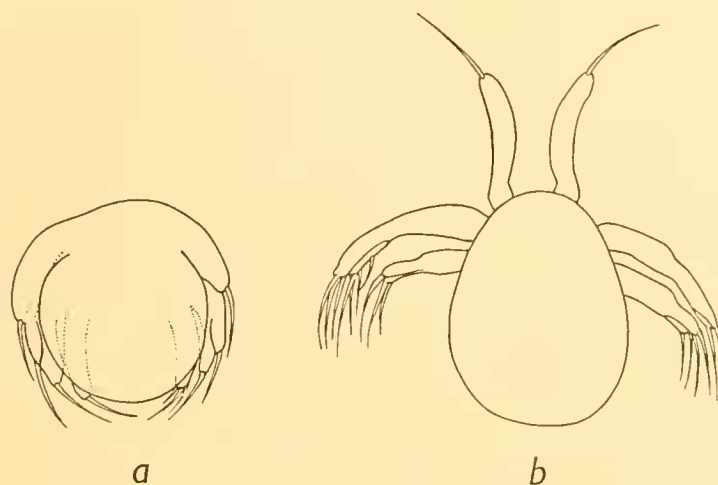


Fig. 1. First Nauplius ($\times 46$). *a*, specimen dissected from egg; *b*, free-swimming specimen.

Table IV. *Occurrence of First Nauplius*

Station	Date	Depth m.	Number	Length mm.
537	19. xii. 30	750-500	1	0.63
539	19. xii. 30	250-100	1	0.66

Of the two free-swimming larvae one measured 0.63 and the other 0.66 mm. They were presumed to be *E. superba* from their relatively large size compared with other Nauplii in the plankton, from their similarity to nearly hatched Nauplii dissected from eggs of *E. superba*, and from their occurrence at stations containing recognizable eggs of this species.

The body of the Nauplius is in dorsal aspect oval in shape, broader posteriorly than anteriorly (Fig. 1*b*). It is in form a normal 1st Nauplius with three pairs of swimming appendages. The first pair of limbs is uniramous with the two succeeding pairs biramous.

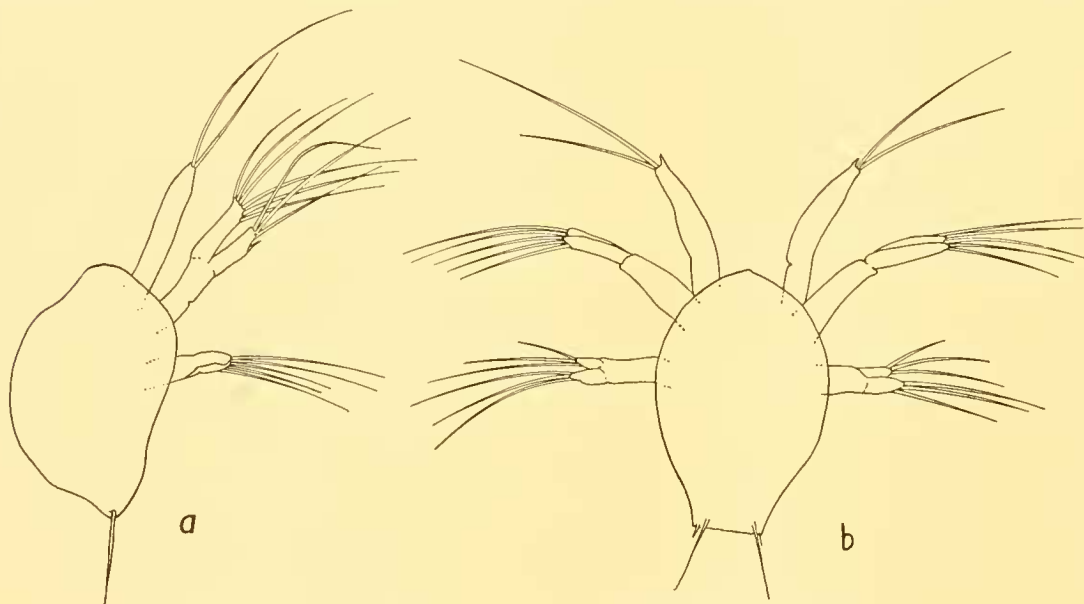
SECOND NAUPLIUS

All the 2nd Nauplii occurred at stations where eggs were present; because of this, but particularly on account of their large size, they were assumed to be *E. superba*. The average length of the 2nd Nauplius is 0.67 mm. with a range of from 0.63 to 0.70 mm.

Table V. *Occurrence of Second Nauplius*

Station	Date	Depth m.	Number	Length mm.	Remarks
540	19. xii. 30	250-100	1	0.70	Female with enlarged ovaries in net A damaged specimen
546	20. xii. 30	250-100	1	0.68	
558	29. xii. 30	200-100	1	0.65	
WS 480	16. xi. 29	500-200	1	0.65	
WS 483	21. xi. 29	500-250	1	0.63	
WS 484	21. xi. 29	750-500	1	0.66	
WS 486	21. xi. 29	500-250	1	0.69	

The outline of the body in dorsal aspect is roughly oval (Fig. 2*b*), truncated at the posterior end and tending to be pointed, rather than rounded, at the anterior end. At each postero-lateral corner of the body there are two spines, a longer inner one about one-quarter to one-third of the length of the body, and a shorter outer one about one-tenth of the length of the first-mentioned spine. Three pairs of appendages are developed (Fig. 2*a*). The antennules are uniramous with two terminal setae; the antennae

Fig. 2. Second Nauplius ($\times 46$). *a*, lateral aspect; *b*, dorsal aspect.

are biramous, having six terminal setae on the inner ramus and three terminal and one lateral on the outer. Posterior to the antennae are the biramous mandibles, each ramus having three setae distally.

METANAUPLIUS

In appearance the Metanauplius is very robust and of great size in comparison with other euphausian Metanauplii found in the same region. The average lengths of the larvae from different stations are given in Table VI. A hundred Metanauplii from St. 647, 750-500 and 1000-750 m. respectively, were measured and give normal length

frequency curves (Table VII), with the two averages closely similar to one another, namely 0.97 and 0.92 mm. The length ranges between 0.90 and 1.05 mm. in the first group and between 0.84 and 0.98 mm. in the second. The extreme range of size is between 0.84 and 1.08 mm. Ruud (1932, p. 47) states that the length of the body in the *Metanauplius* of *E. superba* examined by him is from 0.72 to 0.82 mm. He also states that the carapace of all the specimens was rather swollen, so that his larvae must have been considerably smaller than any found in the present material.

Table VI. *Occurrence of Metanauplius*

Station	Date	Temperature range ° C.	Depth m.	Number	Average length mm.
193	28. iii. 27	-0.26 to -0.66	500-250	1	1.08
618	18/19. ii. 31	0.79 to 0.89	750-500	20	0.92
620	19/20. ii. 31	0.43 to 1.01	750-500	2	0.98
			1000-750	4	0.90
636	8. iii. 31	0.70 to 1.46	750-500	17	0.91 (13)*
637	8. iii. 31	0.03 to -0.22	750-500	24	0.94
			1000-750	10	0.93
638	9. iii. 31	-0.19 to -0.85	250-100	1†	—
			750-500	3	0.93
			1000-750	4	0.91
639	9. iii. 31	-0.76 to -0.99	50-0	2	0.95
647	12. iii. 31	1.34 to 2.01	750-500	3702	0.97 (100)*
			1000-750	577	0.92 (100)*
648	12. iii. 31	1.11 to 3.76	50-0	7	0.85
			100-50	49	0.93 (47)*
			250-100	4	0.93
			500-250	9	0.94 (3)*
WS 197	17. iv. 28	1.33 to 1.27	1000-750	115	0.96 (88)*

* The figure in brackets is the number from which the average length was calculated when all specimens were not measured.

† Larva damaged.

Table VII. *Length frequencies of Metanauplius from St. 647*

750-500 m.			1000-750 m.		
Micro-divisions	Length mm.	Frequency	Micro-divisions	Length mm.	Frequency
56	0.90	4	52	0.84	2
57	0.92	2	53	—	—
58	0.94	10	54	0.87	5
59	0.95	22	55	0.89	16
60	0.97	41	56	0.90	21
61	0.98	5	57	0.92	25
62	1.00	7	58	0.94	17
63	1.02	3	59	0.95	7
64	1.03	4	60	0.97	5
65	1.05	2	61	0.98	2
Av. length 0.97 mm.			Av. length 0.92 mm.		

The carapace (Figs. 3 *a*, *b*) which envelops the anterior portion of the body and part of the abdomen is without marginal spines or processes. It is tucked in under the body posterolaterally, so that when it is dissected and flattened out (Fig. 3 *d*) the posterior portion is wider than the anterior. At the anterior margin of the body underneath the carapace a small pair of frontal sense organs can be distinguished. There are traces

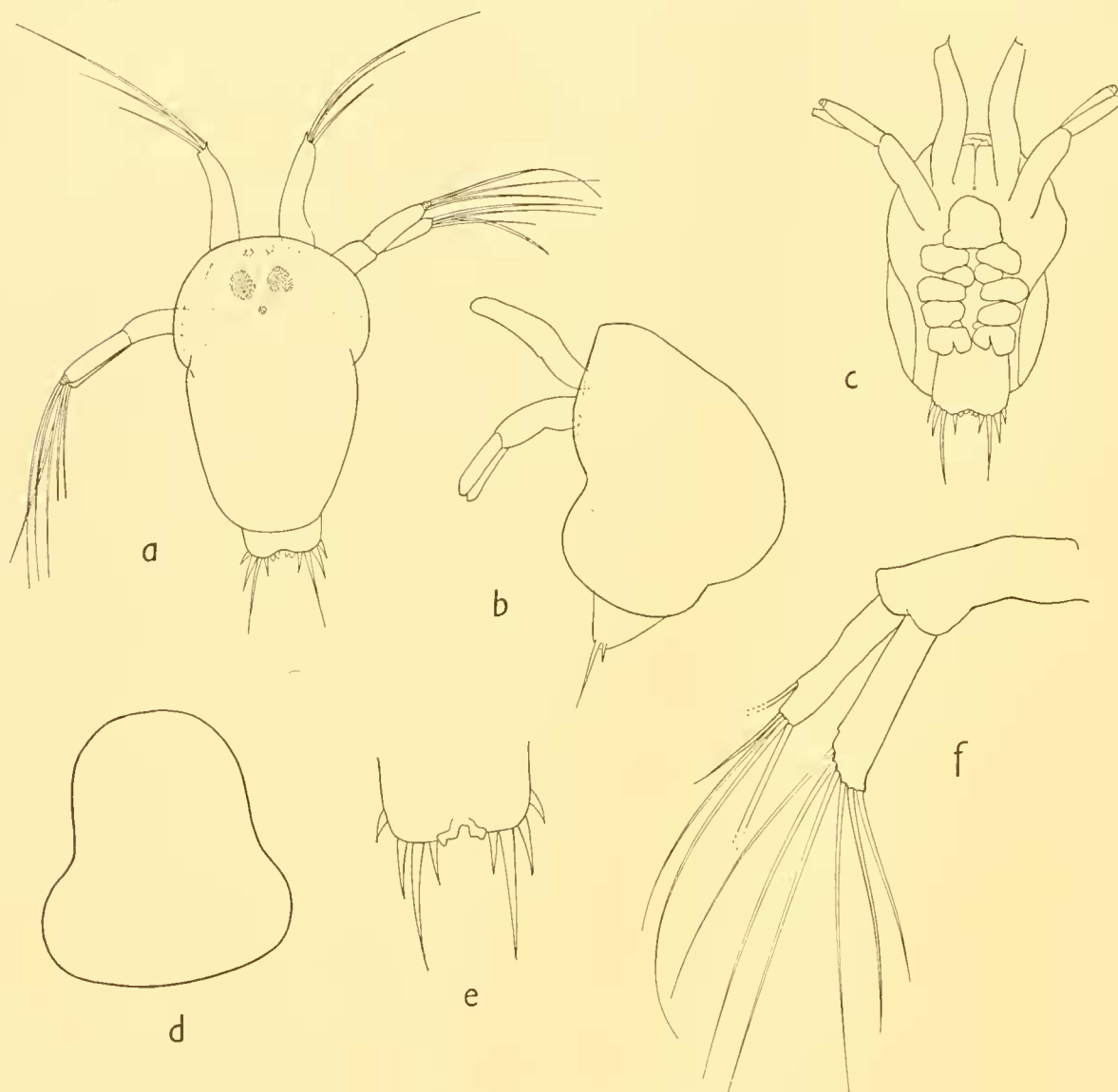


Fig. 3. Metanauplius.

a, dorsal aspect ($\times 46$);

b, lateral aspect ($\times 46$);

c, ventral aspect ($\times 46$);

d, extended carapace ($\times 46$);

e, telson ($\times 100$);

f, antenna ($\times 100$).

In Figs. 3 *b* and *c* the bristles on the appendages have been omitted.

of the paired eyes of the adult and of the median eye, although the latter is not easily seen. The compound eyes are in the form of two roughly spherical masses, and each contains a bunch of fibres within its tissues which is the developing luminous organ of the ocular peduncle (cf. Metschnikoff, 1869, pp. 479, 481, fig. xxxvi). The abdomen is

short, tapering in lateral view and slightly bilobed in dorsoventral aspect. The posterior margin (Fig. 3 *e*) is armed with twelve spines, of which the pair on either side of the emargination are very short and incompletely separated from one another.

The antennules are unsegmented and uniramous, bearing three long bristles at their tips. The antennae (Fig. 3 *f*) are biramous and also furnished with long bristles. The mandibles are in this stage reduced and bud-like in appearance. Maxillae I and II are rudimentary single-lobed buds, and the first thoracic legs are small bilobed processes without setae. Anterior to the mandibles lies the labrum and posteriorly between the mandibles and the 1st maxillae the bilobed labium (Fig. 3 *c*).

FIRST CALYPTOPIS

The average lengths and the ranges of length for varying numbers of 1st Calyptopis are stated in Table VIII. The extreme range for 500 individuals from an oblique net fished at St. 647 is between 1.33 and 1.92 mm. The frequency distribution of these larvae is as follows:

Length, mm.	1.33	1.38	1.41	1.46	1.50	1.54	1.58	1.63	1.67	1.71	1.75	1.79	1.83	1.88	1.92
Frequency	3	1	1	3	7	19	41	51	78	62	78	73	67	15	1

Their average length is 1.71 mm. The lengths of all the other larvae fall within the limits of the stated range, as do the lengths of those examined by Ruud (1932, p. 47).

The carapace is without teeth or projections (Figs. 4 *a*, *b*). The median eye is present, and anterior to it are indications of the compound eyes. The rudiment of the ocular luminous organ can clearly be distinguished as a dark mass of fibres within the developing compound eye. There is also a pair of frontal sensory organs anteriorly.

The appendages, with one or two small differences in detail, are as described by Sars (1885) in *Nyctiphanes australis*. The two sensory appendages on the antennules are difficult to see in unstained specimens. The antenna (Fig. 4 *c*) is composed of a two-segmented peduncle and, distally, an inner and outer ramus as in the *Metanauplius*. In the mandible (Fig. 4 *d*) the dentiform projection between the dentate part and the molar protuberance is present; also, as in *N. australis*, the denticulated plate—the lacinia mobilis. At the base of the projection, where the plate is inserted, there is a bunch of setae surrounding it. The palp of the 1st maxilla consists of two segments as mentioned by Ruud (1932); it bears five spines as opposed to six in *N. australis*, three being at the tip of the distal segment and two on the inner margin of the proximal segment. The inner masticatory lobe is furnished with seven spines of varying structure and the outer lobe with three (Fig. 4 *e*). The larval exopod is as in Sars' description. The 2nd maxilla (Fig. 4 *f*) differs only from Sars' description in having three instead of four bristles on the terminal segment. The 1st thoracic limb (Fig. 4 *g*) differs from that figured by Sars for *N. australis* in having a short bristle at the articulation of the exopodite and the basipodite on the external margin.

The posterior portion of the body, behind the wrinkling of the integument which foreshadows the segmentation of later stages, is shorter than the anterior part. The abdomen is furnished with a pair of spines situated marginally but rather ventrally about

one-third of the abdominal length from the distal end (Fig. 4 *h*). At the posterior end of the abdomen there are three pairs of postero-lateral spines increasing in length from the outer to the inner, and six terminal spines which increase in length from the innermost pair outwards. The longest terminal spine is about half the length of the longest postero-lateral.

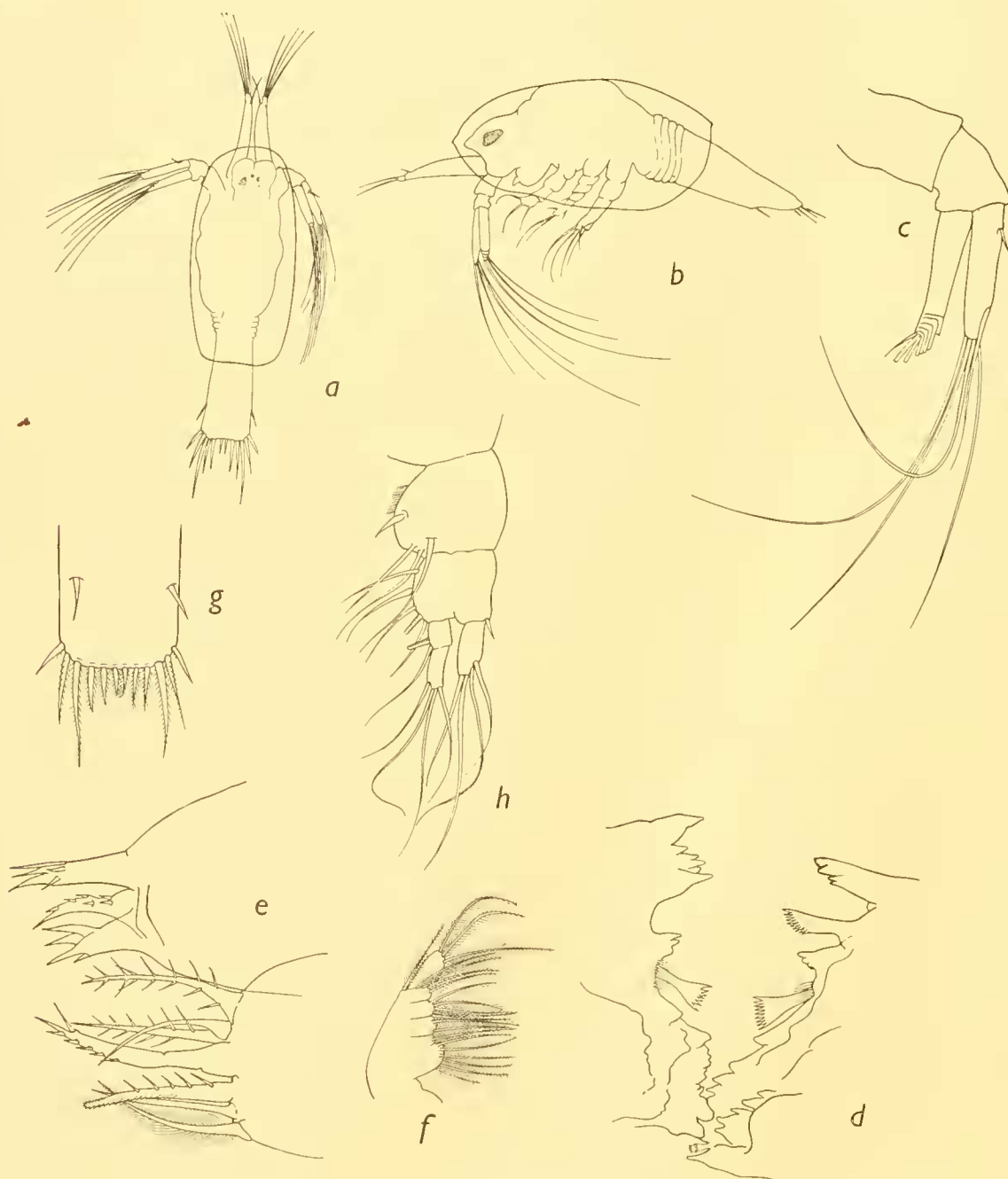


Fig. 4. First Calyptopis.

a, dorsal aspect ($\times 20$);

b, lateral aspect ($\times 25$);

c, antenna ($\times 65$);

d, mandibles ($\times 335$);

e, masticatory lobes of the first maxilla ($\times 315$);

f, second maxilla ($\times 70$);

g, telson ($\times 70$);

h, first thoracic (limb) $\times 70$.

Table VIII. Occurrence of *First Calyptopis*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
161	14. ii. 27	100-50	1	1	1.71	1.71
169	22. ii. 27	500-250	3	3	1.54-1.79	1.65
194	28. iii. 27	100-50	3	3	1.79-1.88	1.85
		250-100	3	3	1.75-1.88	1.79
198	3. iv. 27	50-0	1	1	1.92	1.92
202	5. iv. 27	50-0	1	1	1.88	1.88
302	21. i. 30	500-250	1	1	1.75	1.75
305	21. i. 30	100-50	2	2	1.63-1.67	1.65
313	25. i. 30	750-500	1	1	1.71	1.71
319	29-30. i. 30	100-50	1	1	1.54	1.54
320	30. i. 30	500-250	1	1	1.63	1.63
332	31. i. 30	250-100	5	5	1.50-1.63	1.54
356	10. ii. 30	250-100	1	1	1.58	1.58
357	10. ii. 30	100-50	3	3	1.67-1.71	1.70
		250-100	2	2	1.75-1.88	1.82
365	2. iii. 30	250-100	1	1	1.75	1.75
378	13. iv. 30	50-0	1	1	1.79	1.79
		100-50	1	1	1.75	1.75
383	14. iv. 30	100-50	122	50	1.63-1.79	1.69
		250-100	24	6	1.63-1.88	1.72
618	18-19. ii. 31	50-0	142	99	1.58-1.88	1.75
		100-50	196	90	1.46-1.88	1.70
		250-100	5	5	1.67-1.79	1.74
		750-500	4	4	1.58-1.67	1.63
620	19-20. ii. 31	50-0	59	59	1.46-1.79	1.66
		100-50	148	100	1.50-1.83	1.70
		250-100	11	11	1.46-1.88	1.64
		750-500	10	10	1.42-1.75	1.58
		1000-750	6	6	1.50-1.67	1.58
622	20-21. ii. 31	50-0	30	5	1.67-1.75	1.70
		100-50	11	11	1.58-1.79	1.68
636	8. iii. 31	250-100	5	5	1.58-1.75	1.69
		500-250	31	28	1.46-1.88	1.64
		750-500	1	1	1.58	1.58
637	8. iii. 31	100-50	2	1	1.54	1.54
		250-100	21	21	1.42-1.75	1.59
		500-250	66	63	1.46-1.83	1.68
		750-500	2	—	—	—
		1000-750	4	4	1.58-1.71	1.67
638	9. iii. 31	500-250	4	4	1.58-1.75	1.67
		750-500	2	2	1.54	1.54
639	9. iii. 31	50-0	2	2	1.75-1.79	1.77
		100-50	117	100	1.42-1.88	1.63
		250-100	91	86	1.46-1.88	1.68
		500-250	3	3	1.58-1.75	1.65
		750-500	5	5	1.67-1.83	1.74
646	11. iii. 31	250-100	1	1	1.79	1.79
		500-250	2	2	1.71-1.75	1.73
647	12. iii. 31	50-0	361	100	1.46-1.83	1.63
		100-50	20	20	1.46-1.75	1.62
		250-100	94	87	1.46-1.88	1.69
		500-250	150	100	1.42-1.79	1.60
		750-500	282	50	1.42-1.88	1.68
		1000-750	7	7	1.50-1.79	1.67
648	12. iii. 31	100-50	7	7	1.58-1.71	1.64
		500-250	3	3	1.63-1.67	1.66
WS 139	10. ii. 28	500-250	2	2	1.54-1.75	1.65
WS 141	13. ii. 28	250-100	1	1	1.75	1.75
WS 182	8. iii. 28	250-100	2	2	1.58-1.67	1.63
WS 197	17. iv. 28	250-100	36	36	1.50-1.88	1.70
		500-250	28	28	1.50-1.88	1.71
		750-500	2	2	1.58-1.88	1.73
WS 198	19. iv. 28	250-100	1	1	1.75	1.75
WS 572	8. iii. 31	250-100	1	1	1.75	1.75

SECOND CALYPTOPIS

The average lengths and ranges of length for varying numbers of 2nd Calyptopis are stated in Table IX. The range of forty-eight larvae, the largest number measured in one sample, is between 2.38 and 2.96 mm. and the average is 2.71 mm. The smallest larva measured was 2.13 mm. and the largest 3.33 mm.

The carapace is evenly rounded and there are no lateral denticles (Figs. 5 *a*, *b*). The abdomen is segmented, and in lateral view the developing uropods can be seen within the integument. The telson (Fig. 5 *c*) is furnished with three postero-lateral spines on

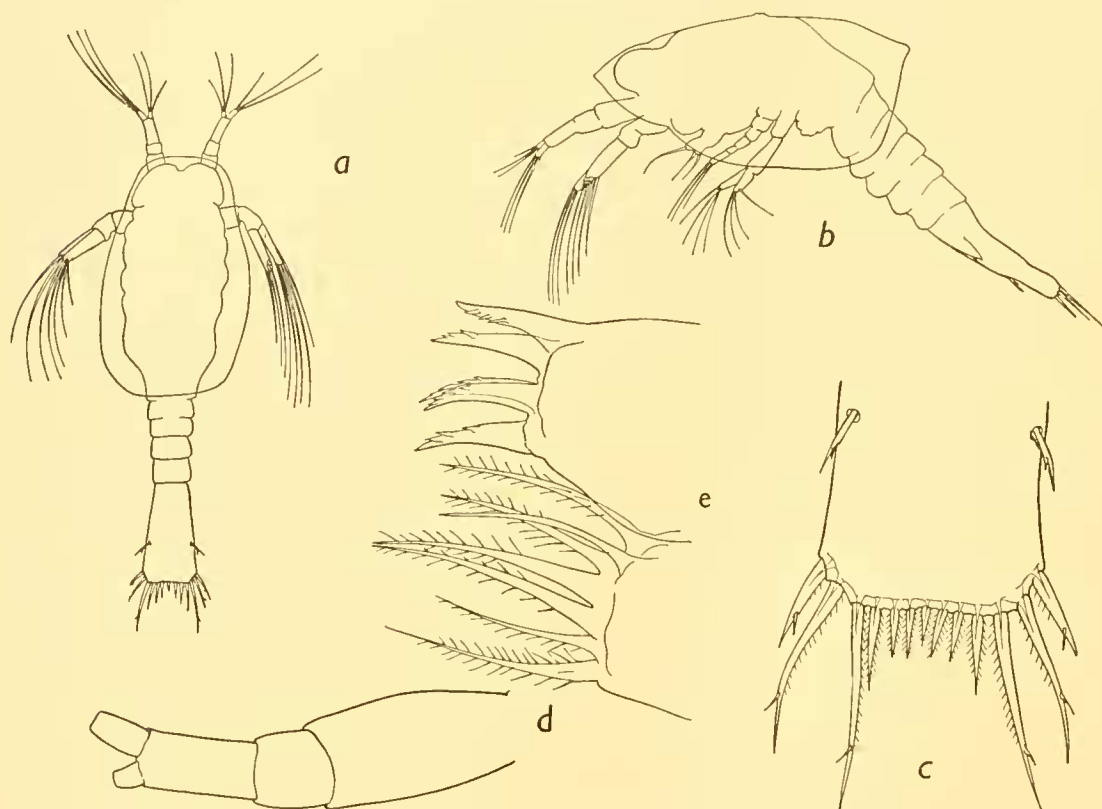


Fig. 5. Second Calyptopis.

a, dorsal aspect ($\times 19$);

b, lateral aspect ($\times 25$);

c, telson ($\times 80$);

d, antennule ($\times 80$);

e, masticatory lobes of the first maxilla ($\times 287$).

each side of the seven terminal spines. A spine is situated laterally on each side of the telson, as in the 1st Calyptopis. Both lateral and postero-lateral spines carry a diminutive dorsal spinule just beyond the middle of their length, as described by Rustad in *Euphausia frigida*. Posterior to the 1st pair of thoracic appendages are situated ventrally and side by side two roughly hemispherical lobes enclosed by the integument containing the buds of the following five pairs of thoracic legs. These lobes are a distinguishing feature of the 2nd Calyptopis of *E. superba*, and their presence is, of course, associated with the exceptionally early development of the thoracic appendages II–VI in this

Table IX. *Occurrence of Second Calyptopis*

Station	Date	Depth m.	No. of larvae	Number measured	Length range mm.	Average length mm.
161	14. ii. 27	100-50	6	6	2.92-3.21	2.98
167	20. ii. 27	250-100	1	1	2.71	2.71
169	22. ii. 27	500-250	3	3	2.50-2.75	2.61
187	18. iii. 27	100-50	1	1	2.92	2.92
193	28. iii. 27	500-250	11	7	2.92-3.17	3.07
		750-500	1	1	3.00	3.00
194	28. iii. 27	100-50	29	26	2.42-3.13	2.80
		250-100	17	17	2.42-3.00	2.72
197	3. iv. 27	100-50	1	1	2.92	2.92
		750-500	1	1	2.92	2.92
		1000-750	2	2	2.92-2.96	2.94
198	3. iv. 27	50-0	22	21	2.63-3.13	2.94
		100-50	5	5	2.71-3.08	2.92
		1000-750	1	1	2.92	2.92
199	3. iv. 27	500-250	2	2	3.00-3.08	3.04
202	5. iv. 27	50-0	3	3	2.54-2.79	2.68
204	6. iv. 27	500-250	3	3	3.00-3.13	3.07
205	6. iv. 27	215-100	2	2	2.92	2.92
206	6. iv. 27	250-100	2	2	3.00-3.13	3.07
209	14. iv. 27	150-100	1	1	2.75	2.75
302	21. i. 30	250-100	2	2	2.50-2.58	2.54
		500-250	6	6	2.71-2.92	2.79
303	21. i. 30	500-250	33	25	2.50-2.96	2.69
		750-500	1	1	2.71	2.71
304	21. i. 30	500-250	2	2	2.63	2.63
305	21-22. i. 30	100-50	5	5	2.46-2.63	2.54
		250-100	4	4	2.58-2.71	2.61
		500-250	2	2	2.63-2.83	2.73
313	25. i. 30	250-100	1	1	2.63	2.63
319	29-30. i. 30	50-0	5	1	2.58	2.58
320	30. i. 30	250-100	1	1	2.42	2.42
		500-250	28	17	2.42-2.67	2.54
321	30-31. i. 30	100-50	3	3	2.46-2.50	2.49
323	31. i. 30	500-250	5	5	2.50-2.67	2.59
		1000-750	1	1	2.67	2.67
332	2-3. ii. 30	250-100	2	2	2.42-2.50	2.46
344	7-8. ii. 30	100-50	2	2	2.42-2.71	2.52
345	8. ii. 30	180-100	1	1	2.58	2.58
356	10. ii. 30	250-100	8	8	2.58-2.96	2.74
		500-250	1	1	2.63	2.63
357	10. ii. 30	100-50	1	1	2.29	2.29
		250-100	2	2	2.42-2.58	2.50
358	11. ii. 30	50-0	11	11	2.58-2.75	2.67
		100-50	3	3	2.50-2.71	2.61
361	25. ii. 30	100-50	1	1	2.79	2.79
362	25. ii. 30	50-0	48	48	2.38-2.96	2.71
		250-100	1	1	2.79	2.79
365	2. iii. 30	50-0	2	2	2.96-3.00	2.98
		250-100	44	44	2.71-3.33	2.99
		500-250	5	5	2.92-3.17	3.04
378	13. iv. 30	50-0	6	6	2.67-2.96	2.84
		100-50	2	2	2.88-2.92	2.90

Table IX (*cont.*)

Station	Date	Depth m.	No. of larvae	Number measured	Length range mm.	Average length mm.
383	14. iv. 30	100-50	23	23	2.50-2.96	2.71
		250-100	80	20	2.75-3.13	2.95
477	12. xi. 30	100-50	1	1	2.71	2.71
618	18-19. ii. 31	50-0	160	31	2.13-2.67	2.41
		100-50	21	21	2.17-2.63	2.41
620	19-20. ii. 31	750-500	1	1	2.50	2.50
		1000-750	1	1	2.38	2.38
622	20. ii. 31	100-50	1	1	2.58	2.58
635	5. iii. 31	50-0	6	6	2.46-2.79	2.60
		100-50	6	6	2.33-2.63	2.49
		250-100	2	2	2.25-2.67	2.46
636	8. iii. 31	250-100	3	3	2.38-2.46	2.42
		500-250	4	3	2.50	2.50
639	9. iii. 31	50-0	1	1	2.67	2.67
		100-50	39	33	2.38-2.92	2.58
		250-100	25	22	2.21-2.83	2.52
		500-250	1	1	2.21	2.21
		750-500	1	1	2.88	2.88
646	11. iii. 31	250-100	1	1	2.67	2.67
		500-250	4	4	2.63-2.71	2.67
647	12. iii. 31	50-0	6	6	2.63-2.92	2.74
		500-250	1	1	2.54	2.54
854	20. iv. 32	110-0	5	5	2.75-2.83	2.78
		248-98	1	1	2.92	2.92
855	20. iv. 32	125-0	1	1	3.04	3.04
		125-0	50	10	2.83-3.13	2.94
		280-154	4	4	2.71-3.00	2.88
WS 139	10. ii. 28	500-250	1	1	2.88	2.88
WS 141	13. ii. 28	250-100	1	1	2.75	2.75
WS 173	6. iii. 28	100-50	1	1	2.63	2.63
WS 182	8. iii. 28	250-100	2	2	2.42-2.79	2.61
WS 197	17. iv. 28	250-100	13	13	2.50-2.92	2.67
		500-250	8	8	2.33-2.71	2.56
WS 527	30. iii. 30	250-100	1	1	2.42	2.42

species. The size of the lobes varies with the size of the larvae, being inconspicuous in the very small larvae and large and easily noticeable in the larger specimens. The compound eyes are more distinctly defined but do not project beyond the margin of the carapace. The fibres of the developing luminous organ at the base of the eyes can be distinguished in the posterior region of the ocular mass.

The antennule consists of a three-jointed peduncle with two rudimentary flagella distally, the one rather larger than the other (Fig. 5 *d*). The sensory filaments on the outer flagellum are situated terminally; there are none on the inner flagellum. The antennae and mandibles are as in the previous stage. The first maxilla (Fig. 5 *e*) is also similar to that found in the 1st Calyptopis except that the outer masticatory lobe bears five spines instead of three and the palp is indistinctly two-segmented. The 2nd maxilla and the 1st thoracic appendage are, in form, as in the previous stage.

THIRD CALYPTOPIS

The average lengths of varying numbers of individuals are stated in Table X. The extreme range of size is between 3.17 and 4.83 mm. The range for the largest number (fifty-eight) measured from one sample is between 3.50 and 4.58 mm. The lower limit of length is almost 1 mm. less than that given by Ruud (1932, p. 48), but the upper limit agrees closely with his.

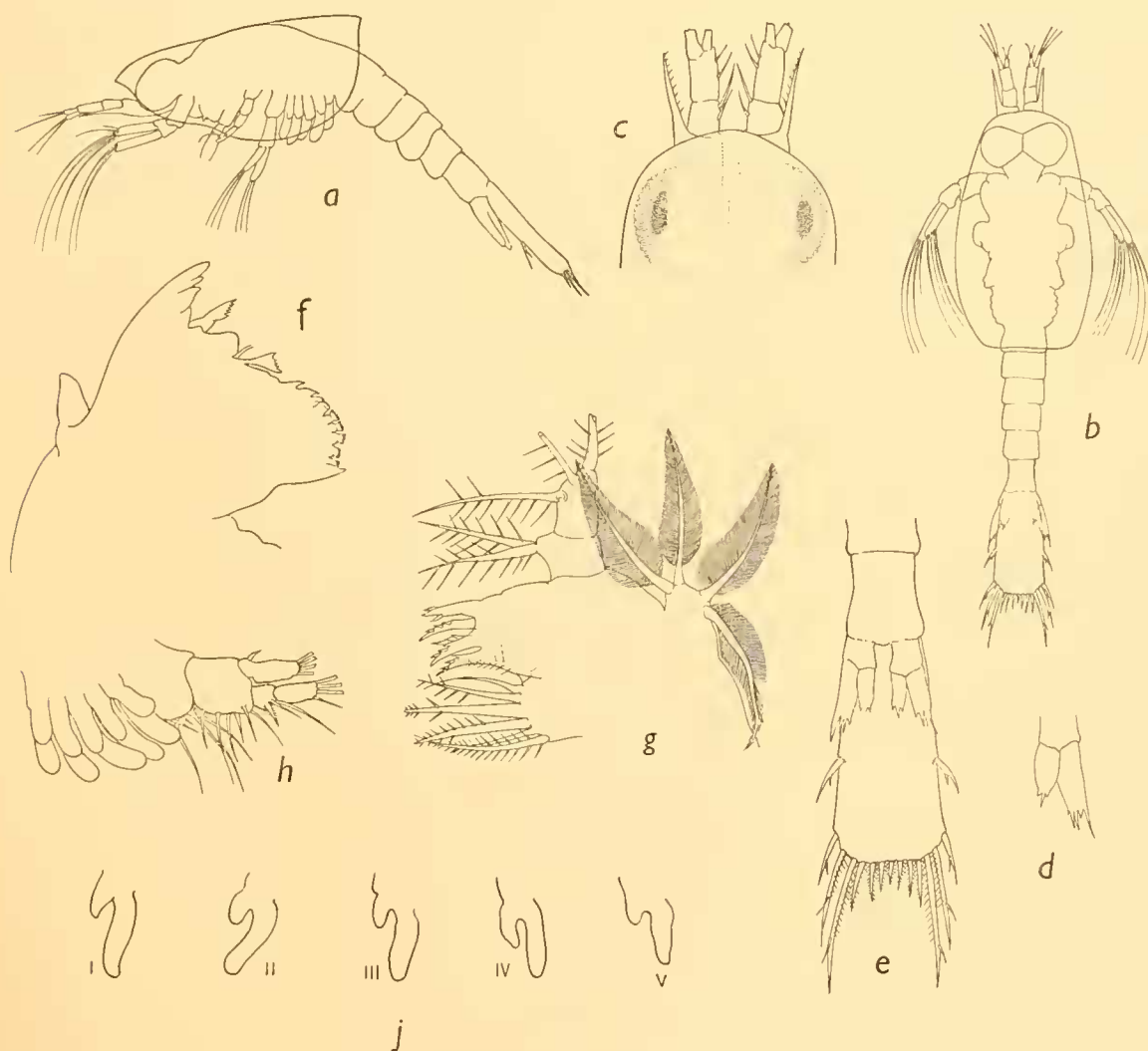


Fig. 6. Third Calyptopis.

- | | |
|--|---|
| <i>a</i> , lateral aspect ($\times 18$); | <i>f</i> , mandible ($\times 165$); |
| <i>b</i> , dorsal aspect ($\times 14$); | <i>g</i> , first maxilla ($\times 110$); |
| <i>c</i> , rostrum and antennules, flagella omitted ($\times 35$); | <i>h</i> , first thoracic limb with limbs II-VI <i>in situ</i> ($\times 35$); |
| <i>d</i> , uropod ($\times 46$); | <i>j</i> , thoracic limbs II-VI ($\times 35$). |
| <i>e</i> , telson, ventral aspect ($\times 35$); | |

The carapace is without lateral denticles (Fig. 6 *a*). In dorsal aspect (Fig. 6 *b*) it completely covers the compound eyes, which are globular in shape and show traces of pig-

Table X. *Occurrence of Third Calyptosis*

Station	Date	Depth m.	No. of larvae	Number measured	Length range mm.	Average length mm.
161	14. ii. 27	250-100	1	1	3.96	3.96
169	22. ii. 27	500-250	7	7	3.67-4.38	4.00
		750-500	1	1	4.79	4.79
187	18. iii. 27	100-50	1	1	4.17	4.17
193	28. iii. 27	500-250	77	50	4.08-4.79	4.48
		750-500	4	4	4.17-4.46	4.40
194	28. iii. 27	100-50	63	58	3.50-4.58	4.06
		250-100	59	48	3.54-4.42	3.84
		500-250	1	1	4.04	4.04
197	3. iv. 27	50-0	1	1	4.29	4.29
		100-50	7	7	3.96-4.46	4.29
		1000-750	2	1	3.92	3.92
198	3. iv. 27	50-0	34	33	3.83-4.83	4.42
		100-50	3	3	4.25-4.38	4.32
		750-500	1	1	4.42	4.42
		1000-750	1	1	4.17	4.17
199	3. iv. 27	500-250	4	4	4.04-4.58	4.28
		750-500	3	3	4.08-4.21	4.15
202	5. iv. 27	50-0	7	7	4.00-4.33	4.15
		500-250	2	2	4.04-4.25	4.15
203	5. iv. 27	250-100	1	1	3.83	3.83
204	6. iv. 27	500-250	2	2	4.58-4.75	4.67
205	6. iv. 27	215-100	2	2	4.04-4.08	4.06
300	20. i. 30	500-250	15	3	3.58-3.88	3.76
302	21. i. 30	250-100	2	2	3.96-4.17	4.07
		500-250	2	2	3.96-4.04	4.00
303	21. i. 30	500-250	90	50	3.67-4.29	4.01
304	21. i. 30	500-250	22	22	3.63-4.33	4.05
305	21-22. i. 30	100-50	1	1	3.54	3.54
		250-100	1	1	4.29	4.29
313	25. i. 30	250-100	5	4	4.00-4.29	4.10
319	29-30. i. 30	250-100	3	3	3.67-4.17	3.92
320	30. i. 30	500-250	60	40	3.67-4.04	3.87
321	30-31. i. 30	100-50	1	1	3.75	3.75
		1000-750	1	1	3.96	3.96
323	31. i. 30	500-250	5	4	3.54-3.83	3.64
324	1. ii. 30	250-100	1	1	3.50	3.50
		500-250	1	1	3.42	3.42
332	2-3. ii. 30	250-100	3	3	3.54-3.75	3.67
335	4-5. ii. 30	50-0	1	1	3.63	3.63
344	7-8. ii. 30	100-50	1	1	3.54	3.54
345	8. ii. 30	180-100	5	5	3.54-4.08	3.80
356	10. ii. 30	250-100	8	8	4.25-4.54	4.41
357	10. ii. 30	100-50	1	1	3.83	3.83
358	11. ii. 30	50-0	6	6	3.79-3.96	3.88
		100-50	1	1	4.04	4.04
360	24. ii. 30	100-50	1	1	3.79	3.79
361	25. ii. 30	50-0	2	2	3.96-4.38	4.17
		100-50	1	1	3.96	3.96
		250-100	18	9	3.54-4.21	4.03
362	25. ii. 30	50-0	138	50	3.33-4.25	3.78
		100-50	2	2	3.58-4.08	4.33
		250-100	50	50	3.38-4.46	3.94

Table X (cont.)

Station	Date	Depth m.	No. of larvae	Number measured	Length range mm.	Average length mm.
365	2. iii. 30	50-0	11	11	4.08-4.75	4.40
		250-100	441	50	4.00-4.75	4.39
		500-250	10	10	4.04-4.79	4.43
368	8. iii. 30	50-0	2	2	3.96-4.38	4.17
		250-100	11	11	4.00-4.33	4.13
		500-250	1*	—	—	—
369	9. iii. 30	50-0	1	1	4.13	4.13
		250-100	12	12	4.08-4.38	4.27
378	13. iv. 30	50-0	1	1	4.17	4.17
383	14. iv. 30	100-50	17	14	3.46-4.17	3.84
		250-100	384	50	3.88-4.58	4.17
618	18-19. ii. 31	50-0	2	2	3.50	3.50
635	7. iii. 31	50-0	9	9	3.17-3.50	3.33
		100-50	2	2	3.29-3.50	3.40
		250-100	1	1	3.25	3.25
636	8. iii. 31	500-250	1	1	3.29	3.29
853	19. iv. 32	119-0	3	3	3.96-4.21	4.07
854	20. iv. 32	119-0	12	7	3.67-3.96	3.84
		248-98	2	2	3.75-3.79	3.77
855	20. iv. 32	125-0	23	23	4.08-4.75	4.35
		125-0	420	50	3.88-4.58	4.27
		280-154	6	6	4.00-4.38	4.11
WS 141	13. ii. 28	500-250	1	1	3.96	3.96
WS 197	17. iv. 28	100-50	1	1	4.17	4.17
		250-100	3	3	3.96-4.17	4.06
		500-250	3	3	3.96-4.13	4.03
WS 198	19. iv. 28	250-100	2	2	4.08-4.17	4.13
		500-250	1	1	4.04	4.04
WS 199	20. iv. 28	500-250	11	11	3.83-4.38	4.13
WS 200	21. iv. 28	500-250	10	10	3.88-4.33	4.10
WS 201	22. iv. 28	50-0	8	8	4.08-4.46	4.25
		100-50	2	2	4.17	4.17
		250-100	1	1	4.04	4.04
WS 527	30. iii. 30	250-100	1	1	3.17	3.17

* Specimen damaged—unmeasurable.

ment. In lateral view the carapace anteriorly is more angular than in the 2nd Calyptopis, and in preserved specimens the eyes may project a very little way beyond its margin. In some of the larger 3rd Calyptopis a clearly defined hyaline area can be distinguished just above each eye in the carapace, a foreshadowing of the emarginations which are present in all later stages.

The abdomen is more elongate than in the 2nd Calyptopis, seven-segmented and longer than the anterior portion of the body. Each uropod (Fig. 6 *d*) consists of a short basal segment bearing two rami, of which the outer is longer than the inner. The outer ramus carries a large spine externally at the tip and two rather small weak spines internally. The inner ramus has a small spine distally. The arrangement of spines at the end of the telson (Fig. 6 *e*) is similar to that of the 2nd Calyptopis.

In the antennule the peduncle consists of three segments, of which the basal is prolonged externally into a strong spine, extending to, or a little way beyond, the distal margin of the distal peduncular segment (Fig. 6 *c*). The flagella are not greatly altered from the form found in the 2nd Calyptopis; the outer flagellum bears two sensory filaments terminally. The antenna, mandible, 1st and 2nd maxilla and the 1st thoracic appendage (Figs. 6 *f, g, h*) are unchanged.

Behind the 1st thoracic appendages are five pairs of bilobed "sausage-shaped" thoracic rudiments (Fig. 6 *g*). In each limb the endopod is longer than the exopod. The posterior limbs are shorter than the anterior; there is no trace of segmentation or setae on the limbs. In Fig. 6 *h* the 1st thoracic limb has been shown along with the succeeding five limbs to compare the difference in size.

The luminous organ at the base of the eye, recognizable as a bunch of fibres, is the only one that can as yet be distinguished.

SUMMARY OF PREVIOUS KNOWLEDGE RELATING TO THE FURCILIA AND CYRTOPIA STAGES

In the report on the Schizopoda collected by H.M.S. 'Challenger' (Sars, 1885), in the section dealing with development of Euphausiidae, it is stated that the three schizopodous genera, Calyptopis, Furcilia and Cyrtopia of Dana were proved by Claus (1863) to be different stages in the development of Euphausiidae. Metschnikoff (1869, 1871) describes still earlier stages, which Sars in accordance with earlier authors designates the Nauplius and Metanauplius stages. For the three succeeding stages Sars applies the generic denominations suggested by Dana. It is the last two of these stages, namely Furcilia and Cyrtopia, which are to be discussed here. They are described by Sars as follows:

Furcilia stage. Compound eyes more fully developed (than in Calyptopis), mobile, and projecting beyond the sides of the carapace. Antennae still retaining their original structure, natatory. Anterior pairs of legs and pleopoda successively developing.

Cyrtopia stage. Antennular flagella becoming elongate and distinctly articulate. Antennae transformed so as not to serve the purpose of locomotion. Posterior legs and gills successively appearing.

Within the division which he terms Furcilia, Sars in his description of *Euphausia pellucida*, Dana (= *E. superba*), recognizes three stages which he names respectively first, intermediate and last Furcilia. Similarly in the Cyrtopia of this species he recognizes two stages, a first and last. The distinction between different stages of both Furcilia and Cyrtopia is based mainly on the degree of development of the appendages.

Referring to the development of *Thysanopoda tricuspidata* Sars states (p. 167) that there are several successive stages of Furcilia in the collection. He only refers to one Cyrtopia stage. In *Nematoscelis rostrata*, G. O. Sars, he recognizes two Furcilia stages and one Cyrtopia.

Brook and Hoyle (1888), describing the metamorphosis of British Euphausiidae, state that in the Furcilia of one species there are eleven moults judging from the comparative development of the pleopods, thus:

Stage 1.	No rudiments of pleopods.				
2.	First pair of pleopods as simple rudiments.				
3.	Second	„	„	„	„
4.	Third	„	„	„	„
5.	Fourth	„	„	„	„
6.	Fifth	„	„	„	„
7.	First pair of pleopods biramous and setose.				
8.	Second	„	„	„	„
9.	Third	„	„	„	„
10.	Fourth	„	„	„	„
11.	Fifth	„	„	„	„

They indicate also that there is more than one Cyrtopia stage, and remark that before the adult stage is reached a large number of ecdyses must take place.

Lebour (1926 c) in a paper entitled "A general survey of larval euphausiids, with a scheme for their identification", recognizes a succession of Furcilia forms commencing with that in which no pleopods are present and followed by others during which the pleopods develop successively until all are setose and biramous. It is stated in this paper that "the pleopods develop in different ways in several different genera, of which the first three or four (forms) are the same and the last two or three are the same, but in between there are different orders of development some of which appear to be characteristic of certain genera". In *Thysanoessa*, for instance, all five pleopods are simple buds before any are setose. In *Euphausia krohnii* the first is setose whilst four are simple. The commonest group found, it is stated, is one which occurs in five genera—*Nyctiphanes*, *Meganyctiphanes*, *Thysanopoda*, *Euphausia*, and *Nematoscelis*—in which the first pleopod is setose with the three following simple and the last not yet formed. In all the genera with the exception of *Euphausia* the second pleopod becomes setose before the last bud appears. Finally in *Stylocheiron* the first pleopod is setose with only two buds behind. This paper later states that the distinctive stages nearly always seem to occur as though certain stages were dominant. Thus in *Stylocheiron* it is Furcilia 7, that is, according to the pleopod development, a form having three pairs of pleopods one pair of which is setose. In *Thysanoessa* it is Furcilia 6, that is, a form having five pairs of non-setose pleopods. In *Euphausia krohnii* it is Furcilia 9, a form in which the pleopod arrangement is one pair setose and four pairs simple. Lebour's paper draws attention to the jumping of stages in some species; it is stated that "Mr Elmhirst and Mr Macdonald from Millport tell me that *Meganyctiphanes* may jump several stages but they always jump into a stage known for that genus. Mr Elmhirst has provided me with some notes on *Meganyctiphanes* (reared in aquaria) in which one jumped from one to three pairs of simple pleopods and one which jumped from three pairs of simple pleopods to three pairs setose and two pairs simple."

Macdonald (1927 b, p. 785), in his paper on "Irregular development in the larval history of *Meganyctiphanes norvegica*", states that the Furcilia is to be recognized by having the eyes no longer covered by the carapace and by the appearance of the pleopods. He distinguished eleven stages of Furcilia, certain of which tended to be dominant and others to be suppressed. He also found that "those Furcilia stages which were observed

to be sometimes omitted during development in captivity were less frequent in the plankton than the other Furcilia stages". "On the other hand", he states, "there were certain stages which predominated in numbers in the plankton." The graph of the frequency of distribution of his eleven Furcilia stages for 302 larvae shows a distinctly bimodal curve, having the one maximum at stage 4 (i.e. three pairs of simple pleopods) and the second at stage 9 (three pairs of setose pleopods and two pairs simple). It is also interesting in this paper to note that of twenty-six larvae kept in aquaria more than half moulted irregularly.

Attention is drawn by Macdonald to further evidence of curtailed larval history provided by another euphausiid, *Nematoscelis microps*, writing of which Lebour states (1926 *d*, p. 766): "The youngest stage found is presumably the second furcilia, measuring 2.4 mm. in length and having one pair of simple bud-like pleopods. . . . The next seen has one pair of pleopods setose and three pairs simple. It is striking that these stages, together with the tenth,¹ seem to be dominant, as no intermediate stages were found whilst these were abundant. Moreover, the sixth and tenth are the stages described by Sars."

Again, on p. 770 Lebour states with reference to *Euphausia krohnii*: "Sars describes the second and seventh furcilia² having one pair of simple pleopods, and one pair setose and four pairs simple respectively. No stages between these two have been found in the Alexandria samples." "The Furcilia with all pleopods setose is presumably the last."

On pp. 768 *et seq.* of this paper on euphausiids from the Mediterranean, Lebour describes the larvae of *Thysanopoda aequalis*, Hansen. "The first furcilia", she states, "the earliest stage seen, measures 2.6 mm. in length. It has no pleopods. The next stage present, measuring 2.9 mm. in length, is probably the third Furcilia having two pairs of simple pleopods. Then apparently several stages are absent and the next seen, measuring 3.5 mm. and probably the seventh Furcilia, has two pairs of setose pleopods and two pairs simple." The following Furcilia stage (text-fig. 2, p. 769) is that in which there are four pairs of setose pleopods and the last pair non-setose.

Rustad (1934, p. 15) shows that in *Euphausia frigida* the Furcilia stages 5, 13 and 14 of Lebour's pleopod diagram are the only ones to be found; these stages are, respectively, forms having four pairs of non-setose pleopods, four pairs setose and one pair non-setose, and all five pairs setose. In the same publication, under *Thysanoessa macrura*, G. O. Sars, and *Th. vicina*, Hansen (the two species are not separated), Rustad states that he found numbers 1, 6 and 14 of the Furcilia stages of Lebour, representing larvae having respectively no pleopods, five pairs of non-setose, and five pairs setose.

Lebour suggests the dominance of certain stages in her earlier paper (1926 *c*) and demonstrates it in the species *Nematoscelis microps*, *Euphausia krohnii* and *Thysanopoda aequalis* (1926 *d*). Macdonald shows that in a sample of *Meganctiphanes norvegica*, where eleven different Furcilia forms occur, two stages are dominant, set apart from one another by an interval of several intermediate stages.

¹ The tenth stage referred to is the tenth for this species, not the tenth stage of Lebour's scheme. The pleopod arrangement is four pairs setose and one pair non-setose.

² The seventh stage here is the 9th Furcilia stage of Lebour's scheme.

It has escaped notice that of the stages which are dominant in the six species just mentioned, the earlier dominant stage bears a direct relationship to the later. This relationship is significant in the consideration of *Euphausia superba* which follows.

The less advanced dominant stage becomes in each species the more advanced by the provision of setae on the non-setose pleopods present in the earlier stage and the addition of one or more pairs of non-setose pleopods. In other words, each pleopod appears first in the non-setose form, and is provided with setae at the next ensuing moult. Thus, in *Nematoscelis* as indicated in Fig. 7 below, the one pair of simple pleopods gives rise

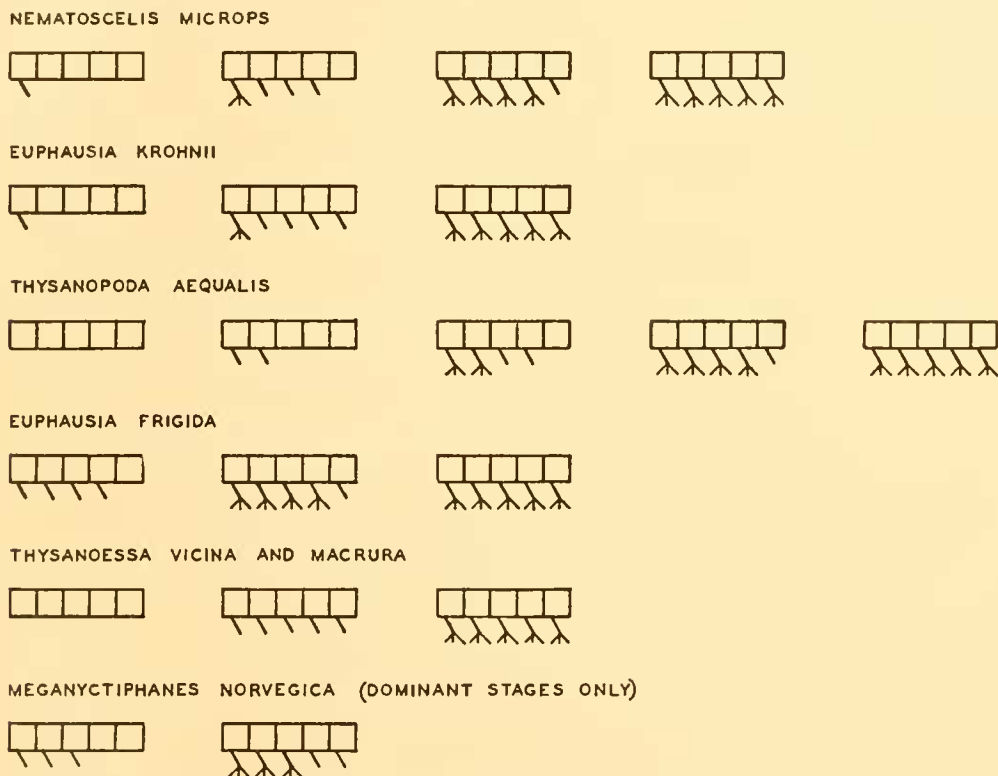


Fig. 7. Diagram to show the relationship of pleopod development and successive dominant stages. In euphausians where the development is known the pleopods appear first in the non-setose form and become setose in the ensuing dominant stage.

to a form having one pair of setose pleopods and three pairs simple, and in the next conspicuous stage these three simple become setose and one non-setose pair is added. A similar method of development takes place in *Euphausia krohnii*, *Thysanopoda aequalis*, *Euphausia frigida* and *Thysanoessa macrura* and *vicina*. *Meganictiphanes norvegica* shows by its dominant stages that a similar process of development is taking place in it also, for the first dominant stage, that having three pairs of non-setose pleopods, is followed by one having three pairs setose and two pairs non-setose.

In a very recent paper by Frost (1935) there is still further evidence of a succession of early Furcilia stages in which non-setose pleopods become setose in the next ensuing moult. The pleopod arrangement in *Nematoscelis megalops* is: Two pairs non-setose—two pairs setose, three pairs non-setose—all five pairs setose. In *Stylocheiron longicorne*

it is: no pleopods—one pair non-setose—one pair setose, two pairs non-setose—three pairs setose, two pairs non-setose—all five pairs setose. Thus in each instance where the number of pleopods at any stage is known it is possible to predict the number of setose pleopods after the next ensuing moult.

EARLY FURCILIA STAGES

Turning now to *Euphausia superba* in the samples used for the identification of Furcilia stages, namely those from 70-cm. nets covering a number of seasons, and from the oblique nets of the circumpolar cruise, fourteen different forms of Furcilia are recognizable by the variation of development in the pleopods.

These forms and their frequency of occurrence are shown in the table below, in which is expressed the number of stations at which the various Furcilia forms were found.

						Number of Stations at which the form was found
(1)	No	pleopods				1
(2)	2	pairs of simple	pleopods			1
(3)	3	"	"	"		5
(4)	4	"	"	"		23
(5)	5	"	"	"		39
(6)	3	"	pleopods, 2	setose, 1	non-setose	1
(7)	4	"	"	1	" 3 "	1
(8)	4	"	"	2	" 2 "	1
(9)	4	"	"	3	" 1 "	1
(10)	4	"	"	all	setose	2
(11)	5	"	pleopods, 2	setose, 3	non-setose	1
(12)	5	"	"	3	" 2 "	2
(13)	5	"	"	4	" 1 "	12
*(14)	5	"	"	all	setose, A and B forms	45

* In this form there are two types of larva recognizable: *A*, a smaller less developed form which normally moults again into *B*, and *B*, larger and more developed and generally moulting into a form with five terminal spines on the telson.

Of the fourteen different Furcilia identified seven occur at one station only, and for six of them the station is the same, namely WS 527. The remaining forms are found at varying numbers of stations, but it will be noted that those occurring at the greatest number of stations are as follows: (1) forms having four or five pairs of non-setose pleopods, and (2) forms having four pairs of setose pleopods and one pair non-setose or all five pairs setose. In other words these are dominant forms comparable to those in *Meganyctiphanes* described by Macdonald.

Analyses of the plankton samples taken with vertical 70-cm. nets at St. WS 527 show that *Euphausia superba* larvae were present in a variety of forms, stated in Table XI below. The number of different kinds of larvae and the frequency of occurrence are shown and the average length of each stage is given. For completeness there have been included Calyptopis stages and Furcilia stages with reduced numbers of spines ter-

minally on the telson, but it is the earlier Furcilia forms up to the point where five pairs of pleopods, all setose, are found which are to be discussed here. Within these limits thirteen different kinds of Furcilia occur. As in the frequency expressed by the number of stations at which they were present, so here, by the frequency of individuals, two maxima are recognizable: (1) larvae having four or five pairs of non-setose pleopods, and (2) larvae having either four pairs setose and one pair non-setose, or all five pairs setose. These are represented in far greater abundance than other combinations of setose and non-setose pleopods and are the dominant stages.

Table XI. *Euphausia superba* larvae from St. WS 527

	Numbers of larvae				Average length mm.
	50-0 m.	100-50 m.	250-100 m.*	Total	
2nd Calyptopis	—	—	4	4	2.42
3rd Calyptopis	—	—	4	4	3.17
Furcilia with no pleopods	—	—	8	8	3.50
„ 2 pairs of non-setose pleopods	—	—	4	4	3.88
„ 3 pairs of non-setose pleopods	—	—	8	8	3.81
„ 4 pairs of non-setose pleopods	—	—	36	36	4.37
„ 5 pairs of non-setose pleopods	—	—	20	20	4.55
„ 3 pairs of pleopods, 2 setose, 1 non-setose	—	—	8	8	4.00
„ 4 pairs of pleopods, 1 setose, 3 non-setose	—	—	4	4	4.58
„ 4 pairs of pleopods, 2 setose, 2 non-setose	—	—	4	4	4.58
„ 4 pairs of pleopods, 3 setose, 1 non-setose	—	—	4	4	4.50
„ 5 pairs of pleopods, 3 setose, 2 non-setose	—	2	4	6	4.81
„ 4 pairs of pleopods, all setose	—	—	32	32	4.84
„ 5 pairs of pleopods, 4 setose, 1 non-setose	—	4	116	120	5.06
„ 5 pairs of setose pleopods. Smaller, Form A	8	10	224	242	5.58
„ 5 pairs of setose pleopods. Larger, Form B	12	1	16	29	6.65
„ 6 terminal spines	4	—	—	4	7.38
„ 5 terminal spines	80	2	—	82	7.79
„ 1 terminal spine	8	—	—	8	10.19

* In this sample only a quarter of the total was analysed.

Inspection of the varying forms of pleopod found amongst the Furcilia at this station shows that without retrogression in development, either in the number of pleopods or in the formation of setae, the larvae cannot moult successively into all the different forms found. Thus those with four or five pairs of non-setose pleopods cannot moult into forms having three pairs of pleopods, two pairs of which are setose and one pair non-setose, without diminishing the number of pleopods. Or if this three-pleopod form be considered less advanced than that having four or five pairs of non-setose pleopods, it cannot moult into one of these latter forms without losing the setae on the first two pairs of pleopods. For the same reasons larvae having two pairs of setose and one pair of non-setose pleopods cannot follow or be followed by forms having one pair setose and three pairs non-setose, nor can larvae having four pleopods, all setose, follow or be followed by forms having five pleopods, three pairs of which are setose and two non-setose.

Anatomical examination of these larvae shows that the progress of development cannot be through a series in which at first non-setose pleopods are successively added, and then by these becoming setose until five setose pleopods result. On the contrary practically every one of the larvae having non-setose pleopods has within the integument the rudiments of setae, so that larvae having two pairs of non-setose pleopods would on moulting become forms having two pairs of setose pleopods and presumably one, two, or three pairs of non-setose pleopods. Larvae with three pairs of non-setose pleopods on moulting become larvae having three pairs of setose pleopods and one or two pairs non-setose, and so on. Thus one would expect to find that the relative abundance of the different kinds of non-setose larvae would be reflected in the setose section and this is what actually happens, for scarce forms such as those with two or three pairs of non-setose pleopods are represented by equally scarce setose forms with two or three pairs setose and one or two pairs non-setose. Likewise those with four or five pairs of non-setose pleopods, which occur abundantly, are followed by equally abundant forms having four pairs setose and one pair non-setose or all five pairs setose.

The suggestion that the larvae moult from forms with non-setose pleopods directly into forms in which those pleopods are setose is supported by the frequency distribution of larvae at stations where a large number occur in the samples. Table XII below shows the larvae from such stations classified according to the condition of the pleopods. The Calyptopis have been included to show that by far the greater number of larvae moult from the third Calyptopis into such as have four or five pairs of non-setose pleopods, and then into larvae having five pairs of setose pleopods or four pairs setose and one pair non-setose.

It is fair to conclude then that in *Euphausia superba* the progress of Furcilia development is from forms in which four or five non-setose pleopods become directly changed on ecdysis into larvae recognizable by having the four or five pairs of non-setose pleopods changed into setose pleopods, and in the former alternative by the addition of one pair of non-setose pleopods. Smaller numbers of non-setose pleopods should be regarded merely as variations of the dominant numbers and, likewise, other combinations of setose and non-setose pleopods should be regarded as infrequently occurring variants of the later dominant form. Thus up to the point when the Furcilia has five pairs of setose pleopods only two Furcilia stages of *E. superba* are recognizable.

INTERPRETATION OF DOMINANT STAGES

Comparing what happens in *E. superba* with what has been observed in *Nematoscelis microps*, *Euphausia krohnii*, *E. frigida*, *Thysanopoda aequalis*, *Meganyctiphanes norvegica*, *Thysanoessa macrura* and *Th. vicina*, I would suggest that the stages recognized as dominant in these species should be regarded as actual stages of that part of the developmental history. Thus in *Nematoscelis microps* the stages referred to as 2nd, 6th and 10th, based on the successive addition of pleopods and by these becoming setose, should be regarded as stages 1, 2 and 3, and so with the other species mentioned above, except *Meganyctiphanes*, in which conditions are somewhat different. In this

last-mentioned genus Macdonald, as already stated, recognized eleven Furcilia, but of these the Furcilia having three pairs of non-setose pleopods and that having three pairs setose and two pairs non-setose are dominant. On analogy with what happens in *Euphausia superba*, particularly with respect to the larvae from St. WS 527, I think it reasonable to suggest that these two "dominant" forms are in fact the first two Furcilia stages, that stages identified by having no pleopods, one pair, two pairs and three pairs of simple pleopods are variants of the early stage and that the remainder with setose pleopods are variants of the 2nd stage.

Table XII. *Frequency of occurrence of larvae of varying form at stations where representative samples were taken*

Station	Calyptopis			Furcilia																Total	
				Pairs of pleopods												Apex of telson					
	First	Second	Third	None	2 simple	3 simple	4 simple	5 simple	2 setose, 1 simple	1 setose, 3 simple	2 setose, 2 simple	3 setose, 1 simple	3 setose, 2 simple	4 setose	4 setose, 1 simple	A. 5 setose;		6 spines	5 spines		
																B. 7 spines					
193	—	12	81	—	—	—	—	26	—	—	—	—	—	—	—	—	—	1	—	—	120
194	6	46	123	—	—	—	2	13	—	—	—	—	—	—	—	—	—	1	—	—	191
198	1	28	39	—	—	—	—	4	—	—	—	—	—	—	—	2	—	9	—	5	88
303	—	34	90	—	—	—	—	7	—	—	—	—	—	—	—	—	2	—	—	—	133
304	—	2	22	—	—	—	—	4	—	—	—	—	—	—	—	—	—	2	—	—	30
305	2	11	2	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	—	—	17
320	1	29	60	—	—	—	5	4	—	—	—	—	—	—	—	—	—	—	—	—	99
332	5	2	3	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	11
361	—	1	12	—	—	—	1	80	—	—	—	—	—	—	—	—	74	8	—	1	177
362	—	49	190	—	—	—	4	90	—	—	—	—	—	—	—	—	9	2	—	—	344
365	—	51	462	—	—	—	—	192	—	—	—	—	—	—	—	—	4	—	—	—	709
368	—	—	14	—	—	—	15	22	—	—	—	—	—	—	—	—	14	1	—	—	66
369	—	—	13	—	—	—	14	12	—	—	—	—	—	—	—	—	9	2	—	—	50
383	146	43	401	—	—	—	5	132	—	—	—	—	—	—	—	—	—	—	—	—	727
635	—	12	11	—	—	2	5	4	—	—	—	—	—	—	—	—	1	—	—	—	35
636	32	4	1	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	39
WS 199	—	—	11	—	—	—	—	31	—	—	—	—	—	—	—	—	17	3	—	—	62
WS 200	—	—	10	—	—	—	—	79	—	—	—	—	—	—	—	—	52	13	—	—	154
WS 201	—	—	11	—	—	—	4	9	—	—	—	—	—	—	1	—	3	1	—	—	29
WS 527	—	4	4	8	4	8	36	20	8	4	4	4	6	32	120	242	29	4	82	—	619

The institution by the early writers of a succession of Furcilia stages, recognized by the addition of pleopods commencing with the pair on the first abdominal segment and later by the provision of setae on these pleopods, is apparently based neither on direct evidence of moulting nor (until Macdonald's work on *Meganctiphanes*) on any quantitative analysis of the material. The result of Macdonald's quantitative investigation has already been stated, and his observations of moulting show that more than half do so "irregularly"; of the remainder which moult "regularly" he does not

indicate from which stage they moult. Whatever they are, the evidence they provide, in conjunction with the "irregularly" moulting individuals, shows in the clearest way that in this species development is not by a well-defined progression of stages in which pleopods are successively added.

It may be well here to quote Rustad (1930, p. 45) in his description of the larval stages of *Euphausia frigida* and *Thysanoessa macrura*. He says: "Development seems to proceed rather schematically up to and including the Calyptopis stages. From the Furcilia stage and upwards it seems on the other hand that there is greater room for action of individual variation. Certainly we observe a clearly pronounced main line which finally leads up to the fully developed adults, but it is impossible to demonstrate any absolute or fixed relation in degree of development between the different organs, and each 'stage' therefore covers a rather broad range of variation in degree of development and form of the single appendage or organ." These remarks should be borne in mind, for they are equally applicable to the development of *Euphausia superba* both with regard to the Furcilia stages already discussed and those which are to be considered in the next section.

Macdonald (1927*b*) quoting Gurney (1924) states that "Among Crustacea, continuous larval development is a primitive feature, whereas a marked metamorphosis is characteristic of more highly developed forms." For this reason Macdonald says "the above observations are interesting as they suggest tentative steps in an evolutionary progress in the order Euphausiacea towards reduction in the number of larval stages. They also suggest that in those arthropods in which the life history consists of a few pronounced stages these are to be regarded not as having evolved independently from a continuous life history, but rather as the survivors of a once greater number of successive stages."

In the light of the evidence provided by *Euphausia superba* and the interpretation of known larval histories in relation to this I consider that it is misleading to talk of a tentative reduction in the *number* of larval stages. This conception is based on the assumption that each variety of pleopod development found indicates a larval stage. It implies that as a primitive phase in the evolutionary history of this group the larvae went through this succession of numerous well-marked changes in form, which is of course contrary to the idea of continuous development. In primitive development one would expect to find no well-marked coincidence of ecdysis with a fixed degree of development. Metamorphosis, as already stated, is a characteristic of highly developed forms. The Euphausiacea should be regarded as coming somewhere between the two extremes, they are arthropods in which "continuous" development is giving way to metamorphosis—already well defined in the Nauplius, Metanauplius and Calyptopis stages, less well defined in early Furcilia by the presence of dominant forms, and still less intelligible in later development. This developing metamorphosis is not essentially a reduction in the *number* of successive stages, but is being brought about by the larvae tending to moult into forms showing a certain degree of development in preference to a lesser or a greater degree.

Continuous development is not an altogether appropriate term to apply to the de-

velopment of any arthropod, since the course of development is in all cases marked off into stages by the occurrence of ecdyses between which no marked change in form usually occurs. Where ecdyses are numerous and the morphological changes occurring at each are slight, the development is of the type to which the term "continuous" has been applied. Where ecdyses are reduced in number while the total change to be achieved remains the same, the amount of change at each moult will obviously increase till it may reach a degree deserving the name "metamorphosis".

Larval specializations requiring elaboration of the straightforward course of development may further increase the extent of change that has to be accomplished at a single moult.

There is a further consideration to which attention may here be drawn. In the more specialized forms with fewer ecdyses the position of each moult on the scale of development, and therefore the changes occurring at each, becomes as it were standardized. In the more primitive cases with so-called "continuous" development the position of the moult may vary, and the changes effected at each are not always identical. The series of moults may, in fact, be regarded as a kind of "grid" superposed on a course of actually continuous development. In the more primitive cases this grid may still shift slightly backwards and forwards; in the more specialized cases the "grid" has become fixed and all individuals show the same changes at each moult.

INTERMEDIATE FURCILIA STAGES

In Table XII above it is indicated that there are two different forms of larvae having all pleopods setose and having seven terminal spines. Examination of the appendages of these Furcilia shows that there is a very great amount of variation in the degree of development. This is most noticeable in the mandibular palp and 1st thoracic limb. There are also differences in size in the antennular flagella, in the postero-lateral spines of the telson and in the shape of the rostrum and telson.

Nine selected larvae of differing sizes from one sample were examined to discover the range of variation occurring in the mandibular palp, 1st thoracic limb and telson. It was seen that the mandibular palp varied between the small bud-like process typical of earlier stages and an elongated three-segmented setose appendage not unlike that found in the adult. The endopod of the 1st thoracic limb could be from twice to three times as long as the exopod and be composed of from two to five segments. The innermost postero-lateral spine on the telson varied in the breadth of the proximal portion; in the smaller larvae the base of the spine was narrow, in the larger ones it was broadened.

It is possible in some of the larvae to determine the number of terminal spines which are to be present when the larva moults (cf. Macdonald, 1928, pl. iv, fig. 10) and it is found that some are to be seven-spined and others five-spined. Before ecdysis the soft tissues draw away from the enclosing integument, and in the telson region particularly the form of the succeeding stage is defined. It cannot be stated for certain in all the larvae, but in those where it is possible the length frequency distribution correlated with the number of spines in the succeeding stage indicates that the smaller forms clearly

tend to moult into larvae, which again have seven spines, while the larger ones moult directly into five-spined forms. This is shown in Table XIII for two samples of seven-spined larvae.

Table XIII. *Length frequencies of larvae with seven terminal spines, arranged according to the number of spines which will be present in the following stage*

Length classes mm.	Following stage				Total
	7-spined	5-spined	6-spined	Uncertain	
5.00-5.24	2	—	—	—	2
5.25-5.49	7	—	—	—	7
5.50-5.74	1	1	—	—	2
5.75-5.99	2	1	1	2	6
6.00-6.24	2	—	—	1	3
6.25-6.49	1	2	—	6	9
6.50-6.74	—	10	1	11	22
6.75-6.99	1	8	—	7	16
7.00-7.24	—	16	—	3	19
7.25-7.49	—	4	—	—	4
7.50-7.74	—	2	—	—	2

There is a considerable overlap in the size ranges of the two groups of larvae in which the number of spines in the succeeding stage can be determined. The normal reduction of the number of terminal spines proceeds by the disappearance of the two outermost, and larvae having six spines should be regarded as exceptional.

The nine larvae mentioned above, when arranged in order of increasing development of the appendages (Fig. 8), furnished a rough scale which was used in the analyses of the samples of seven-spined larvae recorded in Tables XIV and XV. These samples were examined to discover what correspondence, if any, exists between size, degree of development and the numbers of terminal spines in the telson subsequent to moulting. The letters *a* to *j* in the columns of the analyses indicate the form of appendage of the nine larvae which that of the larva in the sample most closely resembled, *a* being the least and *j* the most developed.

In Table XIV the results of an examination of thirty-one larvae are given. It is seen that the rostrum, although it may have a spine in quite small individuals, is in these more often without, whereas in larger larvae there is a greater proportion with a spinous rostral plate. The antennular flagellum increases in length with increasing size of larva. The degree of development of the mandibular palp, 1st thoracic leg and telson within broad limits also correspond with the size of the larva. Here again the fact is demonstrated that smaller larvae moult into seven-spined forms, the larger into five-spined forms, but that there is a great amount of overlapping in size and degree of development.

Table XV shows a similar analysis of larvae from St. 639. The average size of the larvae here is much less than at the previous station cited, and in correlation with this, development is much less advanced; nearly all the larvae indicate that in the following stage they will be seven-spined.

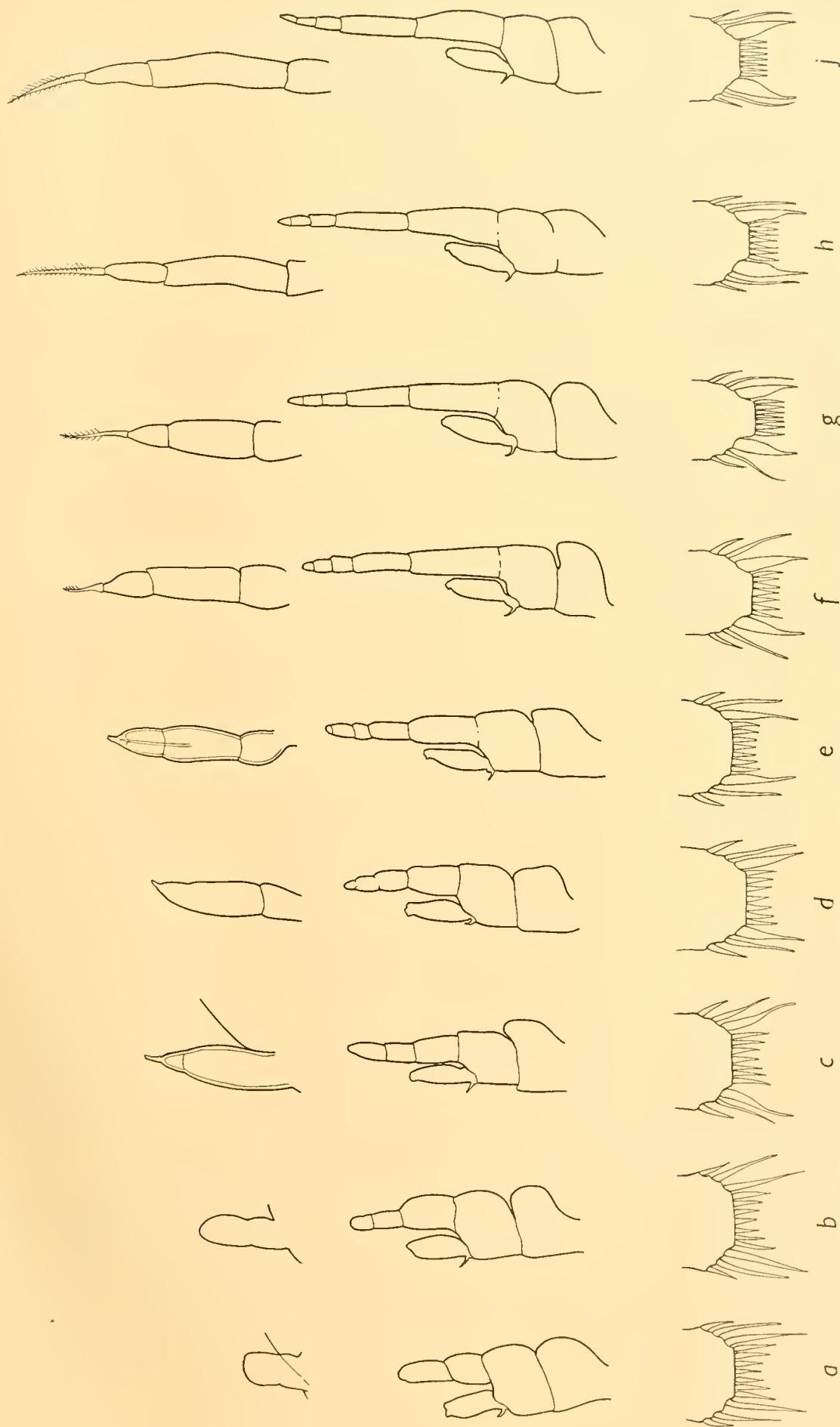


Fig. 8. Appendages of nine selected larvae having seven terminal spines on the telson. The larvae were in length respectively: *a*, 6.04 mm.; *b* and *c*, 6.50 mm.; *d*, 6.71 mm.; *e*, 6.91 mm.; *f*, 6.96 mm.; *g*, 7.04 mm.; *h* and *j*, 7.25 mm. The figures in the upper row are of the mandibular palp, those in the middle row the first thoracic limb and those in the bottom row the telson.

Table XIV. *Analysis of larvae with seven terminal spines on the telson from St. 374*

Length mm.	Rostral spine	Length of antennular flagellum		Form of			Telson No. of spines in succeeding stage	Remarks
		mm.	Micro units	Mandi-bular palp	1st thoracic leg	Telson		
5.08	o	0.19	4.5	a	b	a	7	
5.08	o	0.25	6	b	b	a-c	7	
5.29	o	0.21	5	b	b	a	7	
5.29	o	0.21	5	b-c	b	a	7	
5.42	o	0.21	5	a	b	a	7	
5.71	o	0.25	6	c	d	b-c	5	Note 1
5.88	o	0.31	7.5	c	d	d	6	Note 2
5.88	+	0.36	8.5	f	f	f	5	Note 1
6.17	o	0.33	8	d	e	d-e	7	
6.29	o	0.42	10	g	e	e	7?	
6.33	o	0.42	10	h	h	h	7?	
6.50	o	0.33	8	c-d	e	e	6	Note 3
6.50	o	0.54	13	g	—	f	7?	
6.50	o	0.42	10	h	h	h-j	7?	
6.66	o	0.40	9.5	f	g	g	7?	
6.66	+	0.46	11	g	g	g-h	5	Note 4
6.71	+	0.46	11	f	f	f	7?	
6.75	+	0.46	11	f	f	f	7?	
6.79	+	0.42	10	d	e	f	5	
6.79	o	0.50	12	g	h	f	7	
6.79	+	—	—	g	g	g	7?	
6.92	+	0.54	13	h-j	h-j	j	5	
7.00	+	0.50	12	g	g	f-g	7?	Note 5
7.00	o	0.52	12.5	g	h	h	5	
7.00	o	0.50	12	h	h	h	7?	
7.08	o	0.50	12	f-g	g	g	5	Note 4
7.08	o	—	—	h-j	h-j	h-j	5	
7.08	+	0.58	14	j+	j+	j	7?	Note 6
7.46	o	0.58	14	h-j	h	h-j	5	
7.50	o	0.58	14	j	h-j	h-j	5	
7.58	o	0.58	14	j	j	j	5	

The letters *a-j* in columns 5-7 afford reference to the nine larvae (Fig. 8), which were arranged according to increasing development of their appendages.

Note 1. The two specimens measuring 5.71 and 5.88 mm. respectively will definitely have a five-spined telson in the succeeding stage, although they are of small size and have the less developed appendages generally found in larvae which will again moult into a seven-spined form.

Note 2. Into the outermost left-hand terminal spine of the telson there projects a very thin filament, whilst the corresponding spine on the right side has projecting into its interior a definite process similar to those found within the remaining spines.

Note 3. There will be six well-developed spines in the next stage, the projection into the outermost right-hand spine being completely absent.

Note 4. Within the integument of the telson there are definite projections into five of the terminal spines. The outermost spines on each side have tiny processes projecting into them. The latter would probably atrophy and the succeeding stage would almost certainly be five-spined.

Note 5. The outermost spines have processes projecting into them which are almost as well defined as the others, but preparation for the following stage has not gone far enough to say whether the succeeding stage will be seven- or five-spined.

Note 6. The formation of seven spines is indicated within the integument of the existing terminal spines, but the outermost on each side is much less robust than the remaining five and would possibly have degenerated before the larva moulted.

Table XV. *Analysis of larvae with seven terminal spines on the telson from St. 639*

Length mm.	Rostral spine	Length of antennular flagellum		Form of			Telson. No. of spines in succeeding stage	Remarks
		mm.	Micro units	Mandibular palp	1st thoracic leg	Telson		
5.46	o	0.21	5	a	a	a	7	Note 1
5.91	o	0.25	6	a	a	a	7	
6.00	o	0.27	6.5	a	a	a-b	7	
6.08	o	0.25	6	a-b	a-b	a-b	7	
6.08	o	0.29	7	a-b	a	a-b	7	
6.12	o	0.29	7	b	a	a-b	7	
6.13	o	0.29	7	a-b	a	a	7	
6.21	o	0.27	6.5	—	a	a-b	7	
6.21	o	0.27	6.5	b	a	a-b	7	
6.25	o	0.31	7.5	b	a	a-b	7	
6.25	o	0.31	7.5	b	a	a-b	7	
6.25	o	0.29	7	b	a	a-b	7	
6.38	+	0.29	7	b	a	a-b	7?	
6.46	+	0.42	10	f	e	d-e	7?	
6.75	+	0.38	9	g	d	d-e	7	

The letters *a-j* in columns 5-7 afford reference to the nine larvae (Fig. 8), which were arranged according to increasing development of their appendages.

Note 1. The 5th pleopods are non-setose.

Table XVI gives the results of examination of sixty-one seven-spined larvae from St. 374. In addition to the degree of development as in the two previous tables, the lengths of the mandibular palp, 1st thoracic appendage, and inner antennular flagellum are given both in millimetres and in the units (24 units = 1 mm.) actually employed in measurement.

The length frequency of all the seven-spined larvae from St. 374 is given in Table XVII, in which also is shown the number of specimens which will have seven and five spines in the succeeding stage. The results are shown graphically in Fig. 9.

The length frequency distributions of the mandibular palp, 1st thoracic appendage and inner antennular flagellum, are stated below in Table XVIII and shown

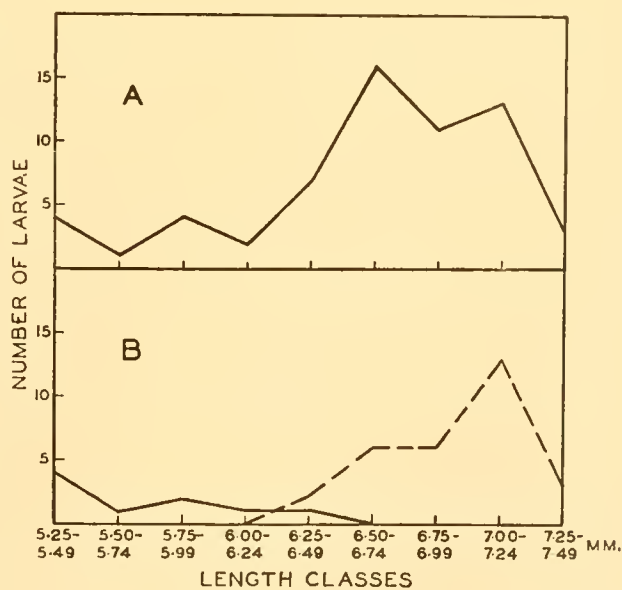


Fig. 9. Length frequency of seven-spined larvae from St. 374. A, all the seven-spined larvae. B, seven-spined larvae in which the telson form in the succeeding stage can be distinguished. — succeeding stage seven-spined. ---- succeeding stage five-spined.

Table XVI. *Analysis of larvae with seven terminal spines on the telson from St. 374*

Length mm.	Rostral spine	Length of antennular flagellum		Mandibular palp			1st thoracic leg			Telson		Remarks
		mm.	Micro units	Form	mm.	Micro units	Form	mm.	Micro units	Form	No. of spines in suc- ceeding stage	
5.25	o	0.23	5.5	b-c	0.42	10	c	2.71	65	a	7	Note 1
5.30	o	0.23	5.5	b-c	0.44	10.5	b	2.63	63	b	7	
5.30	o	0.21	5.0	b	0.44	10.5	b-c	2.75	66	a-b	7	
5.42	o	0.25	6	a	0.38	9	b	2.46	59	b	7	
5.50	o	0.21	5	b	0.54	13	a	2.63	63	a, b, c	7	
5.79	o	0.25	6	c	0.75	18	d	2.92	70	b-c	7	
5.83	o	0.25	6	b	0.46	11	c	2.42	58	b-c	7	
5.83	o	0.48	11.5	g-h	1.08	26	g	3.79	91	g	7?	
5.92	+	0.29	7	e-f	0.83	20	d	3.38	81	c	7?	
6.00	o	0.29	7	c	0.58	14	d	2.96	71	b-c	7	Note 2
6.13	o	0.29	7	c	0.67	16	e	3.75	90	e	7?	
6.25	+	0.29	7	f	0.92	22	f-g	3.58	86	e	7?	
6.25	o	0.31	7.5	f	1.08	26	e-f	3.33	80	b-c	7	
6.38	o	0.38	9	f	1.04	25	e	3.63	87	d-e	7?	
6.42	+	0.50	12	h	1.04	25	h	3.96	95	f	5?	
6.42	o	0.42	10	h	1.21	29	g	3.88	93	f	5	
6.46	+	0.38	9	e-f	0.83	20	e-f	3.88	93	f	5	
6.46	+	0.38	9	g	1.04	25	g-h	3.92	94	f-g	7?	
6.50	o	0.38	9	d-e	0.71	17	e	3.50	84	e	5?	
6.50	o	0.42	10	f	1.04	25	f-g	3.67	88	f	5	
6.54	o	0.38	9	f-g	0.96	23	g	3.96	95	e-f	7?	
6.54	+	0.42	10	f	1.04	25	f	4.17	100	e-f	5	
6.54	+	0.42	10	g-h	1.17	28	g	3.92	94	g	5	
6.54	+	0.42	10	g-h	1.17	28	g-h	4.08	98	h	5?	
6.58	o	0.38	9	g	1.11	26.5	—	—	—	g-h	7?	
6.58	o	0.40	9.5	g	1.17	28	f-g	3.96	95	d-e	7?	
6.63	+	0.38	9	h	0.83	20	f-g	3.54	85	g	7?	
6.63	o	0.33	8	g-h	1.13	27	h	3.71	89	f	7?	
6.63	o	0.38	9	g-h	1.17	28	h	4.08	98	f	7?	
6.63	o	0.44	10.5	h-j	1.29	31	g	3.96	95	g	5	
6.67	o	0.42	10	f	1.00	24	f	3.96	95	f-g	7?	
6.67	+	0.38	9	f	1.25	30	g	4.04	97	f	5	
6.71	o	0.42	10	e-f	0.96	23	f	4.08	98	e-f	5	
6.71	o	0.44	10.5	g-h	1.00	24	g-h	4.17	100	g-h	7?	
6.75	o	0.42	10	f-g	0.96	23	g	3.88	93	f-g	5	
6.75	+	0.42	10	g	1.04	25	g	4.38	105	g-h	7?	
6.75	+	0.46	11	h	1.13	27	h	—	—	g-h	5	
6.75	+	0.46	11	f-g	1.21	29	f-g	4.00	96	f	5	
6.79	o	0.46	11	j	1.13	27	j	4.13	99	j	7?	
6.83	+	0.42	10	g-h	1.21	29	—	—	—	h	5	
6.88	+	0.40	9.5	g	1.08	26	g	3.79	91	f	5	
6.88	o	0.42	10	h	1.21	29	g-h	4.25	102	g-h	7?	
6.88	+	0.50	12	j	1.46	35	h	4.21	101	j	5	
6.92	o	0.42	10	h	1.17	28	g-h	4.08	98	g-h	7?	
6.96	o	0.46	11	h	1.17	28	h	3.92	94	h	7?	
7.00	o	0.44	10.5	g-h	1.21	29	g	4.17	100	h	5	
7.00	+	0.48	11.5	g-h	1.25	30	g-h	3.92	94	h	5	

Table XVI (*cont.*)

Length mm.	Rostral spine	Length of antennular flagellum		Mandibular palp			1st thoracic leg			Telson		Remarks
		mm.	Micro units	Form	mm.	Micro units	Form	mm.	Micro units	Form	No. of spines in succeeding stage	
7.00	+	0.46	11	<i>j</i>	1.25	30	—	—	—	<i>j</i>	5	
7.00	+	0.48	11.5	<i>j</i>	1.25	30	<i>h</i>	4.29	103	<i>h-j</i>	5	
7.00	+	0.44	10.5	<i>h-j</i>	1.29	31	<i>h-j</i>	4.29	103	<i>h-j</i>	5	
7.04	+	—	—	<i>j</i>	1.33	32	—	—	—	<i>h-j</i>	5	
7.08	+	0.46	11	<i>f-g</i>	1.08	26	<i>g-h</i>	3.88	93	<i>h</i>	5	
7.08	+	0.46	11	<i>j</i>	1.46	35	<i>h-j</i>	4.75	114	<i>h-j</i>	5	
7.13	+	0.42	10	<i>g</i>	1.04	25	<i>g-h</i>	3.88	93	<i>g-h</i>	5	
7.13	+	0.48	11.5	<i>j</i>	1.21	29	<i>j</i>	4.04	97	<i>j</i>	5	
7.13	+	0.50	12	<i>h-j</i>	1.25	30	<i>j</i>	4.42	106	<i>j</i>	5	
7.13	+	0.54	13	<i>j</i>	1.33	32	<i>j</i>	4.46	107	<i>h-j</i>	5	
7.16	+	0.52	12.5	<i>j</i>	1.33	32	<i>j</i>	4.38	105	<i>j</i>	5	
7.25	0	0.42	10	<i>h</i>	1.21	29	<i>h</i>	4.33	104	<i>h</i>	5	
7.38	+	0.50	12	<i>j</i>	1.54	37	<i>j</i>	4.42	106	<i>j</i>	5	
7.41	+	0.52	12.5	<i>j</i>	1.38	33	<i>j</i>	4.71	113	<i>j</i>	5	

See footnote to Table XIV (p. 44) for explanation of the letters denoting the form of the mandibular palp, 1st thoracic leg and telson.

Note 1. The left 5th pleopod is non-setose, the right is setose.

Note 2. The mandibular palp is unsegmented. The endopod of the 1st thoracic leg is five-segmented.

Table XVII

Length classes mm.	Total no. of larvae	Following stage		
		7-spined	5-spined	Uncertain
5.25-5.49	4	4	—	—
5.50-5.74	1	1	—	—
5.75-5.99	4	2	—	2
6.00-6.24	2	1	—	1
6.25-6.49	7	1	2	4
6.50-6.74	16	—	6	10
6.75-6.99	11	—	6	5
7.00-7.24	13	—	13	—
7.25-7.49	3	—	3	—
Total	61	9	30	22

graphically in Fig. 10. The graphs for the length frequencies of these appendages are bimodal, a less conspicuous maximum representing the smaller number of larvae of small size in this sample and a more conspicuous one for the bulk of the sample which is made up of large average size.

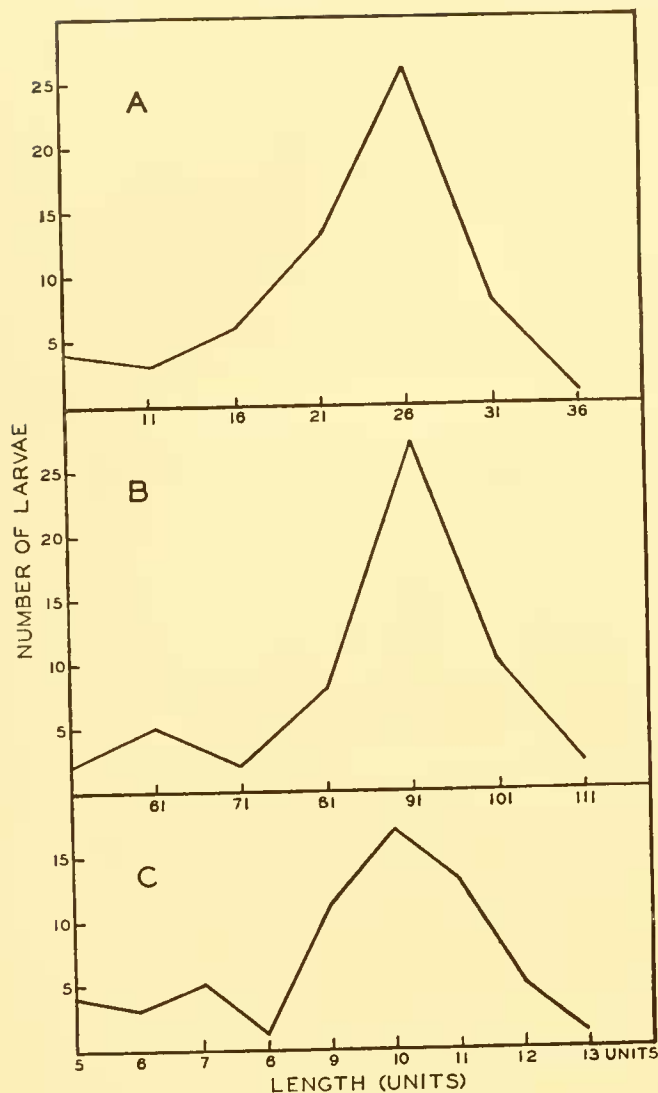


Fig. 10. Length frequencies of: A, mandibular palp; B, first thoracic appendage; C, antennular flagellum.

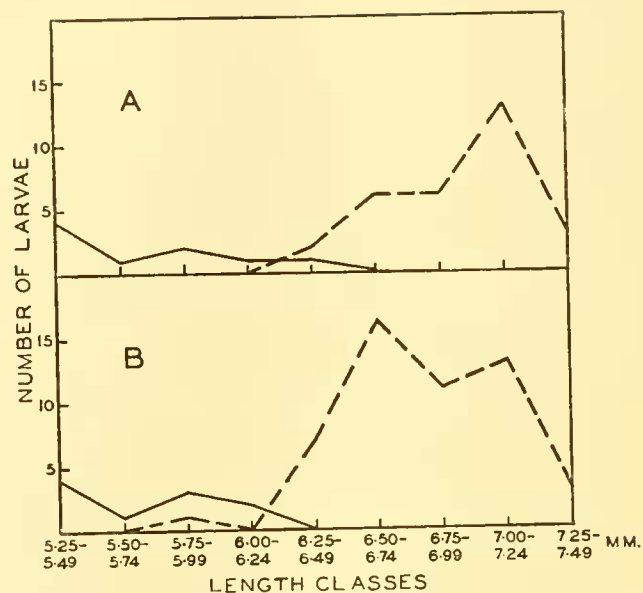


Fig. 11. Length frequencies of larvae with seven-spined telson arranged according to their degree of development.

A, seven-spined larvae in which the telson form in the succeeding stage can be distinguished.

— succeeding stage seven-spined. --- succeeding stage five-spined.

B, seven-spined larvae arranged with reference to nine selected larvae (see Fig. 8).

— degree of development a-d. --- degree of development e-j.

Table XVIII. Length frequencies of mandibular palp, 1st thoracic appendage and antennular flagellum

Mandibular palp			1st thoracic palp			Antennular flagellum		
Length class		No.	Length class		No.	Length class		No.
Units	mm.		Units	mm.		Units	mm.	
6-11	0.25-0.46	4	50-60	2.08-2.50	2	5-6	0.21-0.25	4
11-16	0.46-0.67	3	60-70	2.50-2.92	5	6-7	0.25-0.29	3
16-21	0.67-0.88	6	70-80	2.92-3.33	2	7-8	0.29-0.33	5
21-26	0.88-1.08	13	80-90	3.33-3.75	8	8-9	0.33-0.38	1
26-31	1.08-1.29	26	90-100	3.75-4.17	27	9-10	0.38-0.42	11
31-36	1.29-1.50	8	100-110	4.17-4.58	10	10-11	0.42-0.46	17
36-41	1.50-1.71	1	110-120	4.58-5.00	2	11-12	0.46-0.50	13
						12-13	0.50-0.54	5
						13-14	0.54-0.58	1

If the larvae are arranged in two groups according to their average development as expressed by their correspondence to the scale provided by the nine larvae mentioned above, the result (Table XIX) is two sets of figures which correspond in their range with those of the larvae which are to be seven-spined or five-spined respectively in the following stage. This is shown graphically in Fig. 11.

Table XIX. *Larvae with seven-spined telson from St. 374 arranged in length groups according to their degree of development*

Length classes mm.	Degree of development	
	<i>a-d</i>	<i>e-j</i>
5.25-5.49	4	—
5.50-5.74	1	—
5.75-5.99	3	1
6.00-6.24	2	—
6.25-6.49	—	7
6.50-6.74	—	16
6.75-6.99	—	11
7.00-7.24	—	13
7.25-7.49	—	3

Attention is drawn here to Table XV for specimens from St. 639 in which the average size of the larvae is much less than at St. 374. The larvae compare with the group of larvae of small size at St. 374, and with the exception of two they can, like these latter, be included in the range of development *a* to *d*.

From these analyses, therefore, it is possible to reach the conclusion that in the development of *Euphausia superba* the larvae possessing five pairs of setose pleopods and seven terminal spines can be divided into two groups: (*A*) those having a succeeding seven-spined stage and (*B*) those having a succeeding five-spined stage.

The larvae may be identified as follows:

Form A

Smaller average size.

Antennular flagellum usually shorter than the two distal segments of the antennule.

Mandibular palp sausage-shaped, not generally multiarticulate.

Endopod of 1st thoracic limb not developed as a swimming foot, about twice as long as exopod.

Telson not having innermost postero-lateral spine greatly modified.

Telson length not fully three times the width.

Form B

Larger average size.

Antennular flagellum usually longer.

Mandibular palp distinctly three-segmented and with terminal spine developed.

Endopod of 1st thoracic limb five-segmented, much more than twice as long as exopod.

Telson with proximal portion of the postero-lateral spine widened greatly in comparison with the distal portion.

Telson length more than three times the width.

LATER FURCILIA STAGES

For the development of the larvae after they have the full complement of setose pleopods and less than seven terminal spines on the telson, a random sample of 243 larvae from St. 374 was examined.

The following observations were made:

- Total length of larva.
- Telson: (a) Number of terminal spines.
- (b) Number of postero-lateral spines.
- Number of spines on the telson foreshadowed for the succeeding stage.
- Antenna. Number of segments in inner ramus.
- Mandibular palp: (a) Number of segments.
- (b) Number of spines on the terminal segment.
- 1st thoracic appendage. Number of segments in the endopod.
- Presence or absence of a spine on the rostrum.

In addition to the evidence from these observations, the records of larvae from the 70-cm. net samples generally, and from the oblique and horizontal net samples from the circumpolar cruise have been utilized.

Before proceeding with the discussion of this evidence it is proposed to consider the term "Cyrtopia" applied to euphausian larvae. As stated above (p. 32) the name was applied by Dana to distinguish a schizopodous genus which was afterwards shown by Claus to be a stage in the development of Euphausiidae. Later workers have adopted this division of larval development, and recognize the Cyrtopia by the alteration in form and function of the antenna of earlier stages. Rustad states (1930, pp. 68 *et seq.*): "The Furcilia stages are characterized by having the antennae retained as swimming appendages whereas in the Cyrtopia stages they are directed forwards and evidently have no importance for swimming. In preserved material, however, where the antennae as a rule are directed forwards in late Furcilia stages one must have recourse to morphological characteristics and concerning this Lebour writes (1925, p. 816) 'The best way to distinguish a late Furcilia from an early Cyrtopia is by the flagellum of the antenna which is unjointed in the Furcilia and jointed in the Cyrtopia'."

Considering the indefinite nature of later euphausian development which has already been demonstrated and anticipating the conclusions derived from the sample of larvae from St. 374, it seems that the recognition of the Cyrtopia places too much stress on the alteration of form and function of one particular appendage. The larvae designated Cyrtopia are not recognizable from Furcilia by any sudden increase in size as they change from the old to the altered form. The change in the antenna does not necessarily coincide with equally significant changes in the form of other appendages, for example, the mandibular palp and the 1st thoracic appendage. It varies also in relation to the development of the telson: for the number of terminal telson spines in the first Cyrtopia of various species of euphausians is given as:

<i>Meganctiphanes norvegica</i>	}	7 terminal spines.
<i>Thysanoessa raschii</i>		
<i>Euphausia krohnii</i>	5	"
<i>Nyctiphanes couchii</i>	3	"
<i>Nematoscelis microps</i>	}	1 "
<i>Thysanopoda aequalis</i>		

It is apparent, therefore, that the change in the antenna is not of the significance formerly attributed to it, and the altered form does not merit the distinction of a division

in the larval history. It is merely one of several changes in form, and presumably in function, which take place in the larval appendages in the process of development. These changes are probably intimately connected with the provision of other appendages to do the work performed in earlier stages of the life history by those more anteriorly placed.

The name *Furcilia* will therefore be used here to describe all the later developmental stages in *Euphausia superba*.

The larvae in a sample of 243 individuals from St. 374 have been arranged in Table XX in order of ascending size, and when of the same size roughly according to the degree of development of various appendages.

LENGTH AND TELSON. In Table XXI the larvae have been arranged according to their length frequency. The succession of peaks presented is to some extent made intelligible by distinguishing the larvae according to the number of spines on the telson. There is a correspondence in position of the maxima in the length frequency of all the larvae with those identified according to the telson spine number. Increase in size is accompanied by reduction in the number of telson spines, but there is a great amount of overlapping in the length range of any one telson spine group and the length ranges which succeed and precede it.

The reduction in the number of telson spines is brought about normally by the disappearance of the outermost on either side so that the reduced numbers are 5, 3 and 1. This is not invariable, as the telson spine numbers 6, 4 and 2 indicate in Table XXI; but these forms are present in such small numbers in relation to those with 5, 3 and 1 that they must be regarded as exceptional. Independent evidence in favour of such a conclusion is provided by the frequency, as expressed by the number of stations at which they were found, of larvae having the different forms of telson recognized. Thus:

Larvae with 6 terminal spines occur at 5 stations.

"	5	"	"	"	20	"
"	4	"	"	"	4	"
"	3	"	"	"	11	"
"	2	"	"	"	2	"
"	1	"	"	"	32	"

Several aberrant telson forms are referred to in the notes below the list on p. 53, and some of these are figured (Fig. 12). In three of the figures of unusual telson form the number of spines in the succeeding stage is shown—all three indicate that the aberration of telson form persists when the larva moults.

TELSON SPINE NUMBERS. In Table XXII are stated the length frequencies of larvae arranged according to the number of telson spines in the succeeding stage. Here again, in the seven-spined larvae as in earlier analyses, the smaller ones tend to moult again into seven-spined forms and the larger into five-spined forms. In the five-spined larvae similarly a few moult again into five-spined forms, and there is a surprisingly large number with four spines, but the greater number moult directly into a three-spined form.

In the three-spined larvae it is more difficult to distinguish the number of spines to be found in the succeeding stage, but in those in which it is possible, a succeeding one-spined stage predominates. One larva has two spines in the following stage and there is no sign that any are to be three-spined.

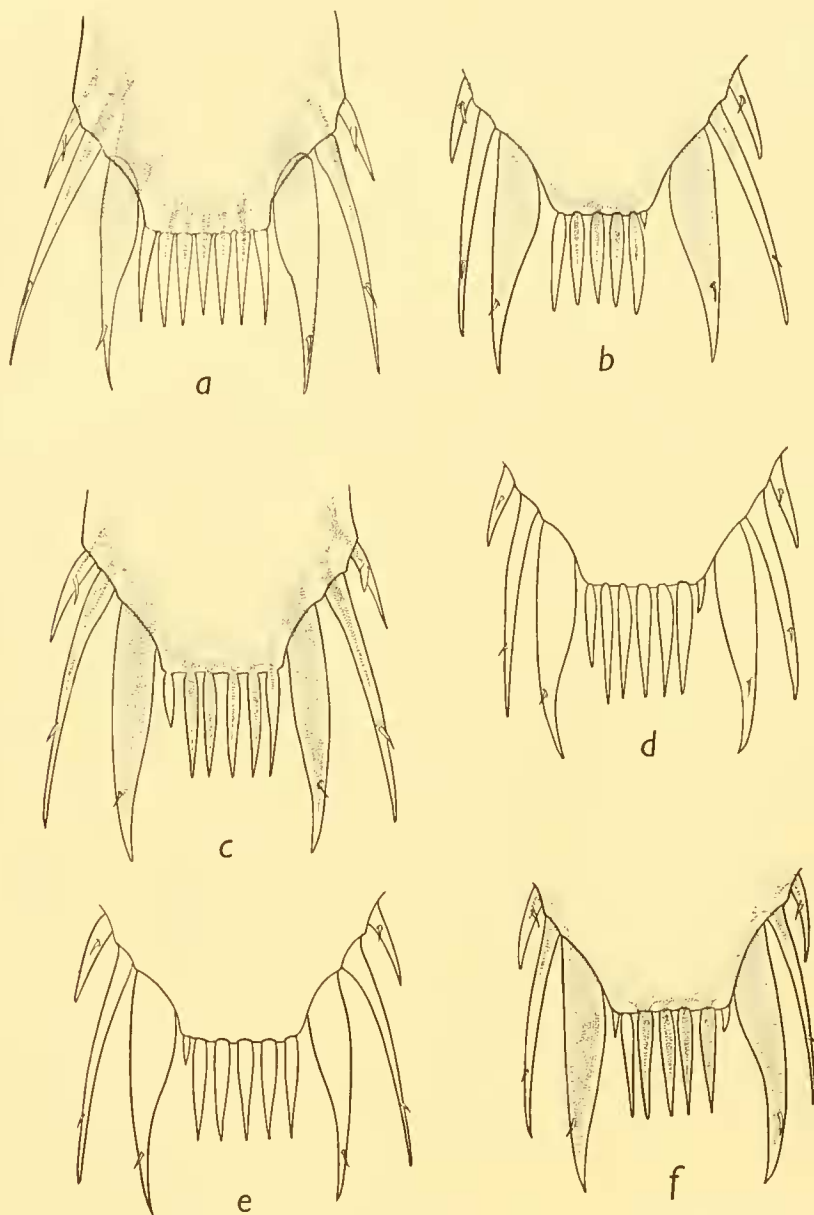


Fig. 12. Normal and abnormal types of telson tip in Furcilia stages ($\times 85$).
a, the normal seven-spined telson. *b-e*, abnormalities.

In Table XX, *b* is referred to under Note 10, *c* under Note 12, *d* under Note 13, *e* under Note 14, *f* under Note 15. In *a*, *b*, *c* and *f*, the form of the telson in the succeeding stage can be distinguished.

It would appear therefore that in the succession of moults which follow on the larvae having five setose pairs of pleopods and the *B* form of telson, the ecdyses generally coincide with a reduction in the number of terminal spines in the telson from seven to

Table XX. *Characters of late Furcilia larvae from St. 374*

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
5.00	7	3 A	...	7	1	Rud.	...	2	Pleopods V non-setose
5.29	7	3 A	o	...	1	Rud.	...	3 or 4	Pleopods V non-setose
5.42	7	3 A	o	7	1	Rud.	...	2	
5.54	7	3 A	...	7	1	3	1	2	Pleopods V non-setose. Note 1
5.63	7	3 A	o	7	1	1	o	2	Pleopods just setose. Note 2
5.67	7	3 A	o	7	1	3	o	3 or 4	Note 3
5.71	7	3 A	o	7	1	3	o	3	
5.75	7	3 A	...	7	1	3	o	3	Note 4
5.75	7	3 A	o	7?	1	3	Rud.	3	
5.82	7	3 A	o	7	1	1	o	2	Missing
6.00	7	3 A	+	...	1	3	1	3	
6.04	7	3 A	o	7	1	1	o	3	Pleopods V non-setose
6.04	7	3 A	...	7	1	2	o	3-4	
6.04	7	3 A	...	7	1	2?	o	5	3?
6.08	7	3 A	o	7	1	1	o	5	
6.21	7	3 A-B	o	7?	1	3	1	5	Note 5
6.29	7	3 B	+	...	1	3	1	5	
6.42	7	3 A-B	+	7?	1	3	1	5	Note 5
6.42	7	3 A-B	o	...	1	3	1	5	
6.42	7	3 A	...	...	1	3	1	5	Note 5
6.46	7	3 B	+	5	1	3	1	5	
6.50	7	3 B	o	5	1	3	1	5	Note 5
6.58	7	3 A-B	o	6	1	Rud.	...	4 or 5	
6.58	7	3 B?	o	...	1	3	1	5	Note 5
6.58	7	3 A-B	o	7?	1	3	1	5	
6.67	7	3	o	...	1	3	1	5	Note 5
6.67	7	3 B	o	...	1	3	1	5	
6.67	7	3 B	+	5?	1	3	1	5	Note 5

Note 1. The mandibular palp is definitely three-segmented with a short terminal spine on the distal segment.

Note 2. The first thoracic appendage is of the primitive form with two-segmented endopod. The distal segment is indistinctly divided into three within the integument.

Note 3. The larva is very near ecdysis, so that the mandibular palp appears six-segmented—the three existing segments and the three of the following stage. The existing cuticle was dissected from the telson leaving the seven terminal spines of the following stage.

Note 4. The one mandibular palp consists of three segments with a very small spine at the tip of the distal one; the palp as a whole is small and sausage-shaped. The other palp is indistinctly three-segmented with no spine at the end.

Note 5. The antennular flagella are only slightly longer than the distal peduncular segment. The mandibular palp is sausage-shaped. The inner ramus of the first thoracic appendage is little more than twice the length of the exopod: it is impossible to state certainly whether it is composed of four or five segments.

Table XX (*cont.*)

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
6.67	7	3 <i>B</i>	o	5	1	3	1	5	Note 6
6.71	6	3	+	...	1	3	1	5	
6.71	7	3 <i>B</i>	o	6	1	3	1	5	
6.71	7	3	...	5	1	3	1	5	
6.75	7	3 <i>B</i>	+	5	1	3	1	5	
6.75	7	3	o	7	1	3	1	5	
6.75	7	3 <i>B</i>	+	5	1	3	1	5	
6.75	7	3 <i>B</i>	o	5	1	3	1	5	
6.79	5	3	...	4	1	3	1	5	
6.83	7	3 <i>B</i>	+	...	1	3	1	5	
6.83	7	3 <i>B</i>	o	5	1	3	1	5	
6.83	7	3 <i>B</i>	o	5	1	3	1	5	
6.83	7	3 <i>B</i>	o	5	1	3	1	5	
6.83	7	3 <i>B</i>	o	5	1	3	1	5	
6.88	7	3	...	...	1	3	1	5	
6.88	5	3	o	...	1	3	1	5	
6.88	7	3 <i>B</i>	o	...	1	3	1	5	
6.88	7	3 <i>B</i>	+	5	1	3	1	5	
6.88	7	3 <i>B</i>	o	5	1	3	1	5	
6.88	7	3 <i>B</i>	+	6	1	3	1	5	
6.88	7	3 <i>B</i>	+	5	1	3	1	5	
6.88	7	3 <i>B</i>	o	5	1	3	1	5	
6.92	5	3	o	...	1	3	1	5	
6.92	5	3	+	...	1	3	1	5	
6.92	7	3 <i>B</i>	...	...	1	3	1	5	
6.92	7	3 <i>B</i>	+	7?	1	3	1	5	
6.96	7	3 <i>B</i>	o	7?	1	3	1	5	
6.96	7	3 <i>A-B</i>	o	5	1	3	1	5	
6.96	7	3 <i>B</i>	o	5	1	3	1	5	
6.96	7	3 <i>B</i>	o	5	1	3	1	5	
6.96	6	3	o	5	1	3	1	5	Note 7
7.00	5	3	o	...	1	3	1	5	
7.00	7	3 <i>B</i>	o	...	1	3	1	5	
7.00	7	3 <i>B</i>	o	5	1	3	1	5	
7.00	7	3 <i>B</i>	o	5	1	3	1	5	
7.00	7	3 <i>B</i>	...	5	1	3	1	5	
7.00	6	3 <i>B</i>	+	...	1	3	1	5	
7.00	5	3	...	3?	1	3	1	5	
7.04	7	3 <i>B</i>	o	5	1	3	1	5	
7.04	5	3	...	5	1	3	1	5	
7.08	7	3	o	5?	1	3	1	5	

Note 6. The five normal terminal spines of the telson are subequal in length; on the extreme left is a small spine less than half the length of the others. There are clearly defined projections into the five larger spines indicating that the succeeding stage will be five-spined.

Note 7. There will be five telson spines in the succeeding stage, there is no projection into the existing spine on the right.

Table XX (*cont.*)

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
7.08	7	3 <i>B</i>	+	5	1	3	1	5?	1st thoracic limb broken
7.08	7	3	...	5	1	3	1	5	Note 8
7.08	6	3 <i>B</i>	o	5	1	3	1	5	
7.08	5	3	...	...	1	3	1	5	
7.08	5	3	o	5?	1	3	1	5	Note 9 Note 10
7.08	5	3	+	3	1	3	1	5	
7.13	6	3	+	5	1	3	1	5	
7.13	5	3	+	4	1	3	1	5	
7.17	7	3 <i>B</i>	...	5	1	3	1	5	
7.17	5	3	...	5	1	3	1	5	
7.17	5	3	+	4	1	3	1	5	
7.17	5	3	+	3	1	3	1	5	
7.21	7	3 <i>B</i>	+	5	1	3	1	5	
7.21	5	3	+	5	1	3	1	5	
7.21	5	3	+	5?	1	3	1	5	Note 11
7.21	5	3	o	3	1	3	1	5	
7.21	5	3	+	3	1	3	1	5	
7.21	5	3	o	3	1	3	1	5	
7.25	7	3 <i>B</i>	+	5	1	3	1	5	
7.25	5	3	o	5?	1	3	1	5	
7.29	7	3 <i>B</i>	...	5	1	3	1	5	
7.29	7	3 <i>B</i>	+	5	1	3	1	5	
7.29	6	3	o	5	1	3	1	5	
7.29	5	3	+	5	1	3	1	5	
7.29	5	3	o	4	1	3	1	5	Note 12 Note 13
7.29	5	3	+	3	1	3	1	5	
7.33	5	3	o	5	1	3	1	5	
7.33	6	3 <i>B</i>	...	4+	1	3	1	5	Note 12 Note 13
7.38	7	3 <i>B</i>	o	5	1	3	1	5	

Note 8. Telson with six terminal spines, but there will be five terminal spines in the following stage. There is no projection into the existing spine on the extreme left.

Note 9. As in Note 6.

Note 10. On the telson the outermost terminal spine on the right is a very small vestige, about one-tenth the length of the spine next to it. Within the integument there are four projections into the spines; there is no projection into the small spine on the right nor into the outermost on the left (see Fig. 12 *b*).

Note 11. As in Note 6.

Note 12. Of the six terminal spines on the telson the outermost on the left is half the length of that next to it. The number of spines in the following stage is four large normal spines and a very small fifth one on the extreme right. The latter may atrophy altogether, so that only four spines may be present in the succeeding stage (see Fig. 12 *c*).

Note 13. Of the seven terminal telson spines, the outermost on the right is one-fifth the length of the next to it, the outermost on the left is about three-quarters the length of that next to it. The remaining spines are subequal with a slight reduction in the size from the outermost to the central (see Fig. 12 *d*).

Table XX (cont.)

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
7.38	7	3 <i>B</i>	+	5	1	3	1	5	Note 14
7.38	6	3 <i>B</i>	+	5?	1	3	1	5	
7.38	6	3	...	5?	1	3	1	5	
7.38	5	3	+	5	1	3	1	5	
7.38	5	3	o	...	1	3	1	5	
7.38	5	3	o	3	...	3	1	5	
7.42	5	3	+	5	1	3	1	5	
7.42	5	3	+	5?	1	3	1	5	
7.42	5	3	+	3?	1	3	1	5	
7.42	5	3	+	3	1	3	1	5	
7.42	5	3	o	3	...	3	1	5	
7.42	5	3	...	3	...	3	2	5	
7.46	5	3	o	5	1	3	1	5	
7.46	5	3	+	4?	1	3	1	5	
7.46	5	3	o	3?	1	3	1	5	
7.46	5	3	o	3	1	3	1	5	
7.50	7	3 <i>B</i>	...	5	1	3	1	5	
7.50	5	3	o	4	1	3	1	5	
7.50	5	3	+	...	1	3	1	5	
7.50	5	3	o	3	1	3	1	5	
7.50	5	3	...	3	1	3	2	5	
7.54	7	3 <i>B</i>	+	5	1	3	1	5	Note 15 Note 16
7.54	7	3 <i>B</i>	o	5	1	3	1	5	
7.54	5	3	o	3	1	3	1	5	
7.58	7?	3 <i>B</i>	o	4	1	3	1	5	
7.58	6	3 <i>B</i>	+	5	1	3	1	5	
7.58	5	3	+	4?	1	3	1	5	
7.58	5	3	o	5?	1	3	1	5	
7.58	5	3	o	3	1	3	1	5	
7.58	5	3	o	3	1	3	1	5	
7.58	5	3	...	3	1	3	1	5	
7.58	5	3	+	3	1	3	1	5	Note 17
7.58	5	3	o	3	1	3	1	5	
7.58	7	3	o	5	1	3	R2, L1	5	
7.63	7	3 <i>B</i>	o	5	1	3	1	5	
7.63	7	3 <i>B</i>	...	5	1	3	1	5	

Note 14. Of the six terminal telson spines the outermost on the left is very small, about one-quarter to one-fifth the length of the next spine to it (see Fig. 12 *e*).

Note 15. Of the seven terminal telson spines, the outermost are only about one-sixth the length of the remainder. There are four projections into the existing spine, there being no projection into either of the small spines nor into the large spine on the left (see Fig. 12 *f*).

Note 16. There are six terminal spines on the telson and there will be five in the following stage; there is no projection into the spine on the extreme right, so that in the existing stage it is the outermost spine on the left which is assumed to be missing.

Note 17. There are seven terminal telson spines; the outermost on each side only about three-quarters the length of the remaining five, which are subequal.

Table XX (cont.)

Total length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
7.63	6	3 <i>B</i>	0	5	I	3	1	5	Note 18
7.63	5	3	...	3	I	3	1	5	
7.67	5	3	+	4	I	3	1	5	Note 19
7.67	5	3	+	...	I	3	1	5	
7.67	5	3	+	3	I	3	1	5	
7.67	5	3	...	3	I	3	R ₁ , L ₂	5	
7.71	7	3 <i>B</i>	+	5	I	3	1	5	
7.71	5	3	+	3	I	3	1	5	
7.79	7	3 <i>B</i>	0	5	I	3	1	5	
7.79	5	3	+	4	I	3	1	5	
7.79	5	3	+	3	I	3	1	5	
7.79	5	3	...	3	...	3	1	5	
7.79	5	3	0	3	I	3	1	5	
7.79	5	3	+	3	I	3	R ₁ , L ₂	5	
7.83	5	3	0	3	I	3	1	5	
7.83	5	3	+	3	I	3	1	5	
7.88	5	3	...	3	...	3	R ₂ , L ₁	5	
7.92	5	3	+	4	I	3	2	5	
7.92	5	3	0	3	I	3	2	5	
7.96	5	3	+	3	Prob. I	3	2	5	
8.00	5	3	0	3	I	3	2, 1	5	
8.00	5	3	...	3	I	3	2	5	
8.04	5	3	...	4	2 + I	3	1	5	
8.13	5	3	...	3	I + I	3	2	5	
8.17	5	3	...	3	I	3	2	5	
8.21	5	3	...	3	I	3	2	5	
8.25	5	3	...	3?	...	3	1	5	
8.25	5	3	+	3	I	3	1	5	
8.29	5	3	+	3	I	3	1	5	
8.29	5	3	...	3	...	3	2	5	
8.33	5	3	+	3	I	3	2	5	
8.38	5	3	...	3	I + I	3	L ₁ , R ₂	5	Note 20
8.38	3	3	+	...	2 + I	3	2	5	
8.46	5	3	...	3	...	3	1	5	
8.54	3	3	...	...	I + I	3	2	5	
8.58	4	3	+	...	I + I	3	2	5	
8.58	3	3	0	...	I	3	2	5	

Note 18. There are six terminal telson spines and there will be five in the next stage. There is no projection into the spine on the extreme left, so that in the existing stage it is the outermost spine on the right which is probably wanting (cf. Note 16 *supra*).

Note 19. Within the integument of the telson four quite well-defined spines are visible. There is no spine projection into the existing spine on the extreme left.

Note 20. There is asymmetry in the development of the appendages of this larva. The left mandibular palp has one large seta, the right two setae on the terminal segment. The left antenna is more primitive than the right, the outer ramus is not scale-like and the inner ramus is very indistinctly divided into two, whereas the left antenna has a definite scale and a distinctly two-segmented flagellum.

Table XX (*cont.*)

Total Length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on term- inal segment		
8.63	5	3	...	3	1	3	2	5	Note 21
8.75	3	3	o	...	1 + 1	3	2	5	
8.79	5	3	+	...	...	3	2	5	
8.79	3	3	...	2	2 + 1	3	2	5	
8.88	3	3	...	...	...	3	3	5	
8.88	3	3	...	...	2 + 1	3	3, 2	5	
8.92	4	3	+	3	1 + 1	3	2	5	
8.92	3	3	+	...	2 + 1	3	R ₃ , L ₂	5	
8.96	5	3	o	3	...	3	1	5	
8.96	5	3	...	...	1 + 1	3	R ₁ , L ₂	5	Note 22
8.96	3	3	+	3?	1 + 1	3	2	5	
8.96	3	3	o	...	...	3	4	5	
9.08	5	3	+	...	...	3	1	5	
9.17	3	3	+	1?	...	3	R ₃ , L ₂	5	
9.21	3	3	+	...	2 + 1	3	3	5	
9.25	3	3	...	...	...	3	2	5	
9.25	3	3	+	...	2 + 1	3	3	5	
9.25	3	3	...	...	2 + 1	3	4, 3	5	
9.33	5	3	...	3?	2 + 1	3	3	5	
9.38	3	3	o	...	2 + 2	3	2	5	
9.38	3	3	+	1?	...	3	R ₃ , L ₂	5	
9.38	3	3	...	1?	...	3	3	5	
9.38	3	3	+	...	2 + 1	3	3	5	
9.38	2	3	+	1	2 + 3	3	3	5	
9.38	3	3	+	3?	2 + 3	3	4	5	
9.46	3	3	+	...	2 + 1	3	2	5	
9.46	3	3	+	...	2 + 1	3	3	5	
9.46	3	3	...	...	2 + 1	3	4, 3	5	
9.54	3	3	...	1	2 + 3	3	2	5	
9.54	3	3	...	...	1 + 1	3	3	5	
9.58	3	3	...	1	2 + 1	3	3	5	
9.58	5	3	...	...	2 + 3	3	4	5	
9.63	4	3	o	...	2 + 1	3	2	5	
9.63	3	3	+	...	2 + 1	3	2	5	
9.63	3	3	o	...	2 + 3	3	3	5	
9.67	3	3	...	...	2 + 1	3	3	5	
9.67	3	3	...	...	2 + 1	3	4	5	
9.71	5	3	+	3?	2 + 1	3	2	5	
9.71	3	3	+	1	...	3	R ₃ , L ₂	5	

Note 21. The inner ramus of the antenna is unsegmented, but within the integument there are definite signs of segmentation indicating that when the animal moults there will be 2 + 1 segments.

Note 22. The inner ramus of the antenna is distinctly divided into two segments, of which the distal gives indication that it becomes three-segmented later.

Note 23. On the telson the terminal spine on the right is only about half the length of the remaining spines.

Table XX (cont.)

Total Length mm.	Telson spines		Rostral spine	Terminal spines of telson in following stage	Segments of inner ramus of antenna	Mandibular palp		Segments of 1st thoracic limb	Remarks
	Terminal	Postero-lateral				Segments	Spines on terminal segment		
9.71	3	3	+	...	2+1	3	3	5	
9.79	3	3	+	...	1+1	3	3	5	
9.79	3	3	+	...	2+1	3	3	5	
9.83	3	3	+	...	2+1	3	2	5	
9.83	3	3	...	...	2+1	3	3	5	
9.83	3	...	...	...	2+3	3	3	5	
9.92	3	3	+	...	...	3	R ₂ , L ₃	5	
9.92	3	3	+	1	2+1	3	3	5	
10.00	5	3	+	3	2+1	3	3	5	
10.00	3	3	o	1?	2+2	3	3	5	
10.00	3	3	o	...	2+3	3	3	5	
10.00	3	3	+	...	2+3	3	3	5	
10.00	3	3	+	...	2+3	3	4	5	
10.00	3	3	+	...	2+3	3	3	5	
10.00	3	3	+	1	2+6 or 7	3	3	5	
10.04	2	3	o	1	2+3	3	3	5	
10.08	3	3	o	...	2+3	3	3	5	
10.08	3	3	+	...	2+3	3	3	5	
10.21	3	3	...	...	2+3	3	4	5	
10.33	3	3	...	...	2+3	3	4	5	
10.38	3	3	+	1	2+3	3	3	5	Note 24
10.46	3	3	o	1	2+3	3	4	5	
10.50	3	3	...	1?	2+3	3	3	5	
10.54	1	3	+	...	2+3	3	4	5	
10.63	3	3	+	...	2+3	3	3	5	
10.63	3	3	+	1	...	3	3	5	
10.67	3	3	+	1	2+3	3	R ₃ , L ₂	5	
10.71	3	3	+	1	2+3	3	4	5	
10.79	1	3	+	...	...	...	...	...	
11.21	1	3	+	...	2+7	3	5	5	
11.46	1	3	o	...	2+9 or 10	3	4	5	
11.58	1	3	+	...	...	3	4	5	
11.71	1	3	+	...	2+4+*	3	4	5	* Broken
12.38	1	3	...	...	...	3	4	5	
12.92	1	3	+	...	...	3	6	5	

Note 24. The antennal inner ramus consists of two basal segments and a three-segmented flagellum. Within the integument of the flagellum can be distinguished a much greater number of segments—six or eight in number at least.

five, five to three and three to one, but that, as might be expected in arthropods whose development is so undefined, by no means all the larvae conform to this scheme.

POSTERO-LATERAL TELSON SPINES. In none of the larvae in this sample is the number of postero-lateral spines reduced from three to two as eventually happens. In the seven-spined larvae the state of development of the innermost postero-lateral is shown in

Table XX by the letters *A* or *B*, these letters corresponding respectively to the forms with narrow and broadened proximal portions. As in the description already given, the form with narrow-based spine is restricted to larvae of smaller size, whereas the broadened form is found in the larger seven-spined larvae. As all later larvae have the broadened form of innermost postero-lateral, the letter *B* has been omitted in descriptions of them.

Table XXI. *Length frequency of larvae from St. 374 arranged according to the number of terminal telson spines*

Length classes mm.	Terminal telson spine number							
	Total	7	6	5	5	3	2	1
5.00-5.24	1	1	—	—	—	—	—	—
5.25-5.49	2	2	—	—	—	—	—	—
5.50-5.74	4	4	—	—	—	—	—	—
5.75-5.99	3	3	—	—	—	—	—	—
6.00-6.24	6	6	—	—	—	—	—	—
6.25-6.49	5	5	—	—	—	—	—	—
6.50-6.74	11	10	1	—	—	—	—	—
6.75-6.99	27	22	1	4	—	—	—	—
7.00-7.24	28	10	3	15	—	—	—	—
7.25-7.49	27	5	4	18	—	—	—	—
7.50-7.74	28	8	2	18	—	—	—	—
7.75-7.99	12	1	—	11	—	—	—	—
8.00-8.24	6	—	—	6	—	—	—	—
8.25-8.49	8	—	—	7	—	1	—	—
8.50-8.74	4	—	—	1	1	2	—	—
8.75-8.99	11	—	—	3	1	7	—	—
9.00-9.24	3	—	—	1	—	2	—	—
9.25-9.49	13	—	—	1	—	11	1	—
9.50-9.74	12	—	—	2	1	9	—	—
9.75-9.99	7	—	—	—	—	7	—	—
10.00-10.24	11	—	—	1	—	9	1	—
10.25-10.49	3	—	—	—	—	3	—	—
10.50-10.74	6	—	—	—	—	5	—	1
10.75-10.99	1	—	—	—	—	—	—	1
11.00-11.24	1	—	—	—	—	—	—	1
11.25-11.49	1	—	—	—	—	—	—	1
11.50-11.74	2	—	—	—	—	—	—	2
11.75-11.99	—	—	—	—	—	—	—	—
12.00-12.24	—	—	—	—	—	—	—	—
12.25-12.49	1	—	—	—	—	—	—	1
12.50-12.74	—	—	—	—	—	—	—	—
12.75-12.99	1	—	—	—	—	—	—	1
Totals	245	77	11	88	3	56	2	8

ANTENNA. The development of the antenna from its primitive form as a swimming appendage into a specialized scale and flagellum takes place within the range of larvae found at this station. The way in which this is brought about is shown in Fig. 13.

The change of the outer ramus into a flattened scale follows the normal course described in other euphausians.

In the inner ramus the unsegmented condition is seen in Fig. 13 *a*. In Fig. 13 *b* this has become divided into two. In Fig. 13 *c* the ramus is still divided into two, but of these the proximal shows a foreshadowing of the two-segmented peduncle of later stages while the distal segment is still unjointed. From this and from the examination of other larvae at this station it is evident that the proximal segment divides into two, forming the peduncle, before segmentation begins in the distal segment. In Fig. 13 *d* the peduncle is distinctly segmented into two and the flagellar portion into four. Within the

Table XXII. *Length frequency of larvae from St. 374 arranged according to the number of telson spines in the following stage*

Length classes mm.	Telson with 7 spines				Telson with 5 spines				Telson with 3 spines		
	Following stage				Following stage				Following stage		
	7-spined	6-spined	5-spined	Uncertain	5-spined	4-spined	3-spined	Uncertain	2-spined	1-spined	Uncertain
5.00-5.24	1	—	—	—	—	—	—	—	—	—	—
5.25-5.49	1	—	—	1	—	—	—	—	—	—	—
5.50-5.74	4	—	—	—	—	—	—	—	—	—	—
5.75-5.99	2	—	—	1	—	—	—	—	—	—	—
6.00-6.24	3	—	—	3	—	—	—	—	—	—	—
6.25-6.49	—	—	1	4	—	—	—	—	—	—	—
6.50-6.74	—	2	3	5	—	—	—	—	—	—	—
6.75-6.99	1	1	14	6	—	1	—	3	—	—	—
7.00-7.24	—	—	8	2	2	2	5	6	—	—	—
7.25-7.49	—	—	5	—	5	1	6	6	—	—	—
7.50-7.74	—	—	8	—	—	2	12	3	—	—	—
7.75-7.99	—	—	1	—	—	2	9	—	—	—	—
8.00-8.24	—	—	—	—	—	1	5	—	—	—	—
8.25-8.49	—	—	—	—	—	—	6	1	—	—	1
8.50-8.74	—	—	—	—	—	—	1	—	—	—	2
8.75-8.99	—	—	—	—	—	—	1	2	1	—	6
9.00-9.24	—	—	—	—	—	—	—	1	—	—	2
9.25-9.49	—	—	—	—	—	—	—	1	—	—	11
9.50-9.74	—	—	—	—	—	—	—	2	—	3	6
9.75-9.99	—	—	—	—	—	—	—	—	—	1	6
10.00-10.24	—	—	—	—	—	—	1	—	—	1	8
10.25-10.49	—	—	—	—	—	—	—	—	—	2	1
10.50-10.74	—	—	—	—	—	—	—	—	—	3	2

integument the state of the flagellum in the following stage can be discerned as having a much greater number of segments.

Rustad (1930, p. 72) describes two different forms of development of the inner ramus of the antenna in euphausians. In the one (Fig. 14 *b*) the flagellum and peduncle are already separated in the two-segmented stage—the *E. frigida* type. In the other (Fig. 14 *a*) the peduncle and flagellum part in the three-segmented stage—the *Thysanoessa macrura* type. *Euphausia superba* (Fig. 14 *c*) follows the *E. frigida* type but differs from it in that the peduncle divides again into two before segmentation of the flagellum

proceeds, whereas in *E. frigida* division of the peduncle coincides with an increase in the number of flagellar segments.

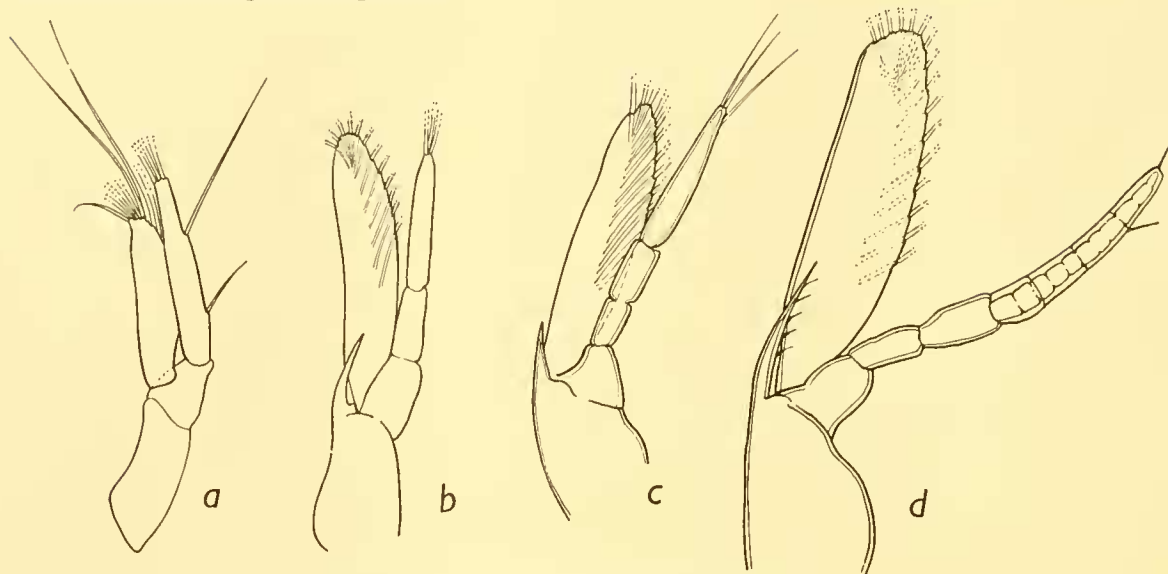


Fig. 13. Development of the antenna ($\times 46$).

a, larva with 5 telson spines;

b, larva 9.16 mm. long with 3 telson spines;

c, larva 9.71 mm. long with 3 telson spines;

d, larva 11.30 mm. long with 3 telson spines.

In the statement of the number of segments in the inner ramus of the antenna of the larvae from St. 374 (Table XX) the number has been expressed as the sum of two, of which the first indicates peduncular and the second flagellar segments.

In Table XXIII the length frequency of the larvae according to the number of terminal spines in the telson and the state of the inner ramus of the antenna are given. None of the seven- or six-spined larvae possess segmented antennal inner rami. Among five-spined larvae 89.7 per cent have unsegmented and 10.3 per cent have segmented antennal inner rami.

The number of four-spined larvae is considerable but all have segmented inner rami. By the time the larvae are three-spined, only a very small minority are unsegmented, and in the two- and one-spined larvae no unsegmented antennae occur. The analysis shows therefore that the change in the form of antenna is not restricted to one stage but may take place in five-spined or three-spined larvae. It also shows that, within

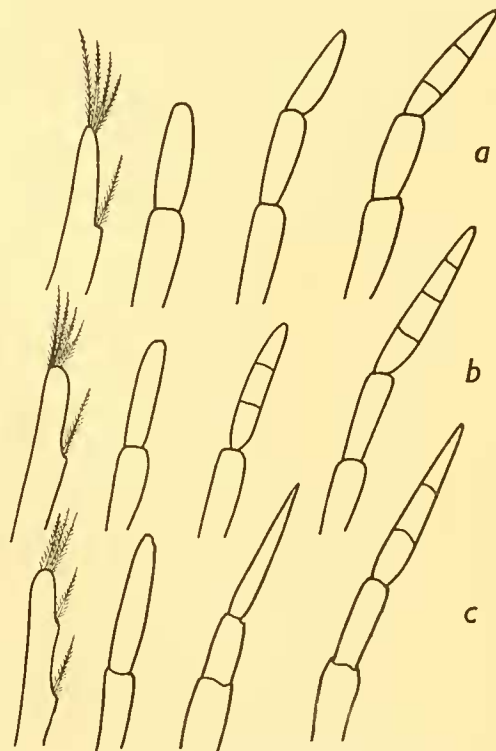


Fig. 14. Segmentation of antennal inner ramus. *a*, *Thysanoessa macrura*; *b*, *Euphausia frigida*; *c*, *E. superba*. Diagrammatic, *a* and *b* after Rustad.

narrow limits at all events, the size does not determine the point at which the antennae should assume the segmented form; for instance, in the five-spined group there is an overlap of 1 mm. in the length distributions of the unsegmented and segmented forms. At the same time, however, it should be noted that of the five-spined larvae which

Table XXIII. *Length frequency of Furcilia larvae from St. 374 divided into groups according to the numbers of spines on the telson and the form of the inner ramus of the antenna*

Length classes mm.	Number of telson spines														Total unsegmented	Total segmented	
	Seven	Six	Five	Four	Three	Two	One										
	Inner ramus of antenna																
	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented	Unsegmented	Segmented			
5.00- 5.24	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	
5.25- 5.49	2	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	
5.50- 5.74	4	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	
5.75- 5.99	3	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	
6.00- 6.24	6	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	
6.25- 6.49	5	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	
6.50- 6.74	10	—	1	—	—	—	—	—	—	—	—	—	—	—	11	—	
6.75- 6.99	22	—	1	—	4	—	—	—	—	—	—	—	—	—	27	—	
7.00- 7.24	10	—	3	—	15	—	—	—	—	—	—	—	—	—	28	—	
7.25- 7.49	5	—	4	—	15	—	—	—	—	—	—	—	—	—	24	—	
7.50- 7.74	8	—	2	—	18	—	—	—	—	—	—	—	—	—	28	—	
7.75- 7.99	1	—	—	—	8	—	—	—	—	—	—	—	—	—	9	—	
8.00- 8.24	—	—	—	—	4	2	—	—	—	—	—	—	—	—	4	2	
8.25- 8.49	—	—	—	—	3	1	—	—	—	1	—	—	—	—	3	2	
8.50- 8.74	—	—	—	—	1	—	—	1	1	1	—	—	—	—	2	2	
8.75- 8.99	—	—	—	—	1	1	—	1	—	5	—	—	—	—	1	7	
9.00- 9.24	—	—	—	—	1	—	—	—	—	1	—	—	—	—	1	1	
9.25- 9.49	—	—	—	—	—	1	—	—	—	8	—	1	—	—	—	10	
9.50- 9.74	—	—	—	—	—	2	—	1	—	8	—	—	—	—	—	11	
9.75- 9.99	—	—	—	—	—	—	—	—	—	6	—	—	—	—	—	6	
10.00-10.24	—	—	—	—	—	1	—	—	—	9	—	1	—	—	—	11	
10.25-10.49	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	3	
10.50-10.74	—	—	—	—	—	—	—	—	—	4	—	—	—	1	—	5	
10.75-10.99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
11.00-11.24	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	
11.25-11.49	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	
11.50-11.74	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	
Percentage	100	—	100	—	89.7	10.3	—	100	2	98	—	100	—	100			

are segmented the length distribution is towards the upper rather than the lower length limit of the five-spined group.

The larvae having segmented antennae show also that the degree of segmentation is generally dependent on size. The lengths and number of segments in the antenna of five-

spined larvae are given in Table XXIV. With the exception of the first, the larvae show a direct relation between size and number of segments.

Table XXIV. *Larvae with segmented antennae and five terminal spines on the telson*

Length mm.	Number of segments
0.04	2 + 1
8.13	1 + 1
8.38	1 + 1
8.96	1 + 1
9.33	2 + 1
9.58	2 + 1
9.71	2 + 1
10.00	2 + 1

There are only three four-spined larvae in which the antennal condition is recorded; of these the two smaller have a two-segmented antenna and the remaining rather larger one three segments.

The relation is most clearly demonstrated in the larvae having three terminal telson spines. In this group there are forty-seven larvae having antennal inner rami varying in development between that which is unsegmented and that in which the inner ramus is composed of two peduncular and more than three flagellar segments. In Table XXV these larvae are set out according to total length and the number of segments in the inner ramus of the antenna. The average length of each group of larvae having the same number of antennal segments is stated. The increase in the number of segments in the antennal endopod varies directly with increase in average length; but as in the size ranges of larvae with unmodified and modified antennae, so here in the number of segments, the size range for any one number of segments overlaps in its lower and upper limits the ranges which precede and succeed it.

Table XXV. *Larvae with three-spined telson. Length frequency and condition of the antennal endopod*

Length classes mm.	Antennal endopod: number of segments					
	1	1 + 1	2 + 1	2 + 2	2 + 3	2 + more than 3
8.25- 8.49	—	—	1	—	—	—
8.50- 8.74	1	1	—	—	—	—
8.75- 8.99	—	2	3	—	—	—
9.00- 9.24	—	—	1	—	—	—
9.25- 9.49	—	—	6	1	1	—
9.50- 9.74	—	1	5	—	2	—
9.75- 9.99	—	1	4	—	1	—
10.00-10.24	—	—	—	1	7	1
10.25-10.49	—	—	—	—	3	—
10.50-10.74	—	—	—	—	4	—
Average length, mm.	8.58	9.12	9.40	9.69	10.13	10.00

In the larvae having a two-spined telson there are only two records of the number of segments in the antennal inner ramus; the number in each is $2 + 3$. The one-spined larvae have antennae segmented as follows:

Length	Segmentation of antennal endopod
10.54	$2 + 3$
11.21	$2 + 7$
11.46	$2 + 9$ or 10
11.71	$2 + 4 +$ (end broken off)

The length distribution of all larvae having segmented antennae, grouped according to the number of segments in the antenna, is given in Table XXVI.

Table XXVI. *Length frequency of Furcilia larvae with segmented antennae arranged according to the number of antennal segments*

Length classes mm.	Number of segments in antenna					Total
	$1 + 1$	$2 + 1$	$2 + 2$	$2 + 3$	$2 + \text{more than } 3$	
8.00-8.24	1	1	—	—	—	2
8.25-8.49	1	1	—	—	—	2
8.50-8.74	2	—	—	—	—	2
8.75-8.99	4	3	—	—	—	7
9.00-9.24	—	1	—	—	—	1
9.25-9.49	—	7	1	2	—	10
9.50-9.74	1	7	—	3	—	11
9.75-9.99	1	4	—	1	—	6
10.00-10.24	—	1	1	8	1	11
10.25-10.49	—	—	—	3	—	3
10.50-10.74	—	—	—	5	—	5
10.75-10.99	—	—	—	—	—	—
11.00-11.24	—	—	—	—	1	1
11.25-11.49	—	—	—	—	1	1
11.50-11.74	—	—	—	—	1	1
Total	10	25	2	22	4	63
Average length, mm.	8.85	8.93	9.69	10.09	11.09	

This arrangement of results shows that, although there is a narrow range of larval length, namely $\frac{1}{2}$ mm., in which it is possible to find any one of the five different forms of segmentation distinguished, the average lengths of the larvae clearly increase with the increasing development of this appendage. Incidentally the relative scarcity of the antennal form $2 + 2$ suggests that the normal process of segmentation of the antennal endopod of *Euphausia superba* is as follows: 1 , $1 + 1$, $2 + 1$, $2 + 3$.

MANDIBULAR PALP. In this appendage the number of segments and the number of spines on the terminal segment were noted.

The change of the mandible from its primitive form takes place entirely within the

group of larvae which has seven terminal spines on the telson—all later larvae (and most of the seven-spined larvae) have the three-segmented form of palp.

Inspection of Table XX shows that larvae can occur having the fifth pair of pleopods non-setose but with the mandibular palp in an advanced stage of segmentation (Note 1).

The majority of larvae which are going to moult again into the second form of seven-spined telson larvae have mandibular palps which are primitive in form, but this is not invariable.

The numbers of segments noted in the mandibular palp, and observations of development within the existing integument, indicate that the general process of development is from one to three segments, although occasional larvae have a two-segmented form.

In Table XXVII the length frequency of the larvae and the number of spines in the mandibular palp are stated. In addition each group of larvae distinguished by the number of spines on the mandibular palp has been divided according to the number of terminal spines on the telson. As in the segmentation of the antennal endopod, so in the mandibular palp, increasing length is accompanied by increase in the number of spines on the palp, but the length range of larvae for any particular spine number overlaps in its upper and lower limits the ranges which precede and succeed it.

Larvae with seven terminal spines may have no spines or one or two spines on the mandibular palp, those with five telson spines may have one, two, three or four spines on the palp and so on, so that no mandibular palp spine number or range of numbers is exclusive to larvae having a particular telson spine number. The general development of course is such that the number of spines on the mandibular palp is increased with decrease in the number of spines on the telson, and, as in the segmentation of the antennal endopod, within any one group distinguishable by the number of telson spines, increase in the number of palp spines is directly connected with the average length of larvae.

FIRST THORACIC APPENDAGE. In the *Calyptopis* and earlier *Furcilia*, the 1st thoracic limb is as shown in Fig. 6, having two basal segments, an exopod consisting of a single segment and an endopod of two segments. As already demonstrated with larvae that have five pairs of setose pleopods and still have the unaltered number of seven terminal spines on the telson, the 1st thoracic limb changes from its primitive condition and the endopod assumes its final form by an increase in segmentation from two to five.

Examination of the data obtained from the larvae from St. 374 indicates that this change invariably takes place before the telson becomes five-spined. In the seven-spined larvae the primitive form of the 1st thoracic limb is confined to the smaller larvae which are going to moult again into a seven-spined form.

ROSTRAL SPINE. The rostrum of each larva was examined to find the frequency of occurrence of the median spine which foreshadows the pointed condition of the adult animal. It is seen that in all forms of larvae distinguished by telson spine number the pointed condition can occur, and that even in larvae having only one terminal spine on the telson it is possible to have the rostral spine undeveloped. The number of larvae which have a rostral spine does, however, increase appreciably as the larvae develop. This is shown in Table XXVIII, where the percentages of the total for each group are

Table XXVII. Length frequency of larvae with reference to number of spines on telson and mandibular palp

Mandibular palp spine number	None	1				2				3				4				5	6
Telson spine number	7	7	6	5	Total	7	5	4	3	Total	5	3	2	Total	5	3	1	1	1
Length classes mm.																			
5.00-5.24	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5.25-5.49	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5.50-5.74	3	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5.75-5.99	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6.00-6.24	4	2	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6.25-6.49	—	5	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6.50-6.74	1	9	1	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6.75-6.99	—	22	1	—	27	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7.00-7.24	—	10	3	4	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7.25-7.49	—	5	4	17	26	1	—	—	—	1	—	—	—	—	—	—	—	—	—
7.50-7.74	—	7	2	16	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7.75-7.99	—	1	—	6	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8.00-8.24	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8.25-8.49	—	—	—	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8.50-8.74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8.75-8.99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.00-9.24	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.25-9.49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.50-9.74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.75-9.99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.00-10.24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.25-10.49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.50-10.74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.75-10.99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.00-11.24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.25-11.49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.50-11.74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.75-11.99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12.00-12.24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12.25-12.49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12.50-12.74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12.75-12.99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	14	62	11	65	138	1	20	3	12	36	2	34	2	38	1	10	5	1	1

also given. The numbers of two- and one-spined larvae are too small to be really indicative of what happens, but from the remaining groups it is clear that the change in form of the rostrum can take place in any one of a number of larval stages, the spinous form tending to be more common in the later than in the earlier stages.

Table XXVIII. *Presence or absence of the rostral spine in late Furcilia larvae*

Number of spines on the telson	Rostral spine			
	Present		Absent	
	Number	%	Number	%
7	21	34	40	66
6	5	55	4	45
5	36	57	27	43
4	2	67	1	33
3	29	76	9	24
2	1	55	1	50
1	4	67	2	33

The examination of these larvae shows that development in *Euphausia superba* in the later Furcilia stages is not a rigidly fixed process in the degree of development of particular appendages in relation to one another. It is only possible to indicate in the most general way the track that development takes.

The analysis also shows what has been referred to at the beginning of this section, namely that in this species the change in form of the antenna is preceded by changes equally fundamental in character in the mandible and the first thoracic appendage. This furnishes a strong argument against the use of the term *Cyrtopia* for larvae with altered form of the antenna. It may be added that John in his paper on the southern species of *Euphausia*, about to be published, shows that in different species the change in form of the antennae can precede, or accompany the changes in the mandibular palp and 1st thoracic limb.

DESCRIPTION OF FURCILIA STAGES

For the purpose of this description the Furcilia forms are classified in the following stages:

FIRST FURCILIA (p. 69). *Pleopods non-setose*. In this stage are included all larvae, in advance of the 3rd Calyptopis, having simple non-setose pleopods.

SECOND FURCILIA (p. 76). *Pleopods setose, postero-lateral and terminal telson spines unaltered*. This stage includes larvae with setose pleopods, up to five pairs in number, having seven terminal spines on the telson and the postero-lateral spines unaltered.

THIRD FURCILIA (p. 84). *All pleopods setose, seven terminal spined telson, postero-lateral spines altered*.

FOURTH FURCILIA (p. 88). *Five terminal spines on the telson*.

FIFTH FURCILIA (p. 92). *Three terminal spines on the telson*.

SIXTH FURCILIA (p. 96). *One terminal spine on the telson, postero-lateral spines not reduced in number.*

This account excludes description of larvae with six-, four-, or two-spined telson; these are rarely occurring aberrant forms which in development are intermediate between those larvae whose telson spine numbers are respectively one greater and one less. Tables giving particulars of these forms are inserted in their appropriate positions.

FIRST FURCILIA

Included in this stage are the following larvae in advance of the 3rd Calyptopis:

(a)	Larvae with no pleopods.
(b)	„ 1 pair of non-setose pleopods.
(c)	„ 2 „ „ „
(d)	„ 3 „ „ „
(e)	„ 4 „ „ „
(f)	„ 5 „ „ „

All these forms, with the exception of (b), are represented in the material examined.

In Table XXIX the non-setose larvae have been separated into groups according to the number of pleopods. At the end of each subdivision the number of larvae, their range of size and average length are stated. An examination of the number of larvae recorded in each subdivision demonstrates the dominance of the (e) and (f) forms, particularly the latter, and the comparative rarity of the others. It will be noted that there is a direct correlation between the number of pleopods and the average sizes in the different groups.

For all the 1st Furcilia the average length is 5.30 mm., and the range is from 3.50 to 6.50 mm.

Larvae having two, three, four and five pairs of non-setose pleopods were examined in detail.

The eyes project beyond the edge of the carapace which has two emarginations anteriorly between which is the rostral plate (Figs. 15 *g, h, j*). In the two-pleopod form the anterior edges of the rostral plate form a very obtuse angle, but in the larvae with more pleopods the rostrum is evenly rounded, reaching not quite to the distal margin of the basal antennular segment in the smaller larvae and still more distant from it in the larger larvae. The smaller larvae have no spine on the postero-lateral margin of the carapace; it is present, but inconspicuous, in the larva with four pairs of pleopods and is quite a distinct denticle in the largest larva in this group (Figs. 15 *a, b, c*).

The telson (Figs. 15 *d, e*) is seven-spined terminally, has three postero-lateral spines and a spine situated laterally on each side about the middle of the telson length. The seven terminal spines have spinules on each lateral edge; the postero-laterals bear them on the inner edge and less obviously dorsally. Both lateral and postero-lateral spines have a somewhat larger spinule than the rest situated dorsally at some distance from the tip. The telson length is more than twice the width except in the smallest larvae in which it is a little less.

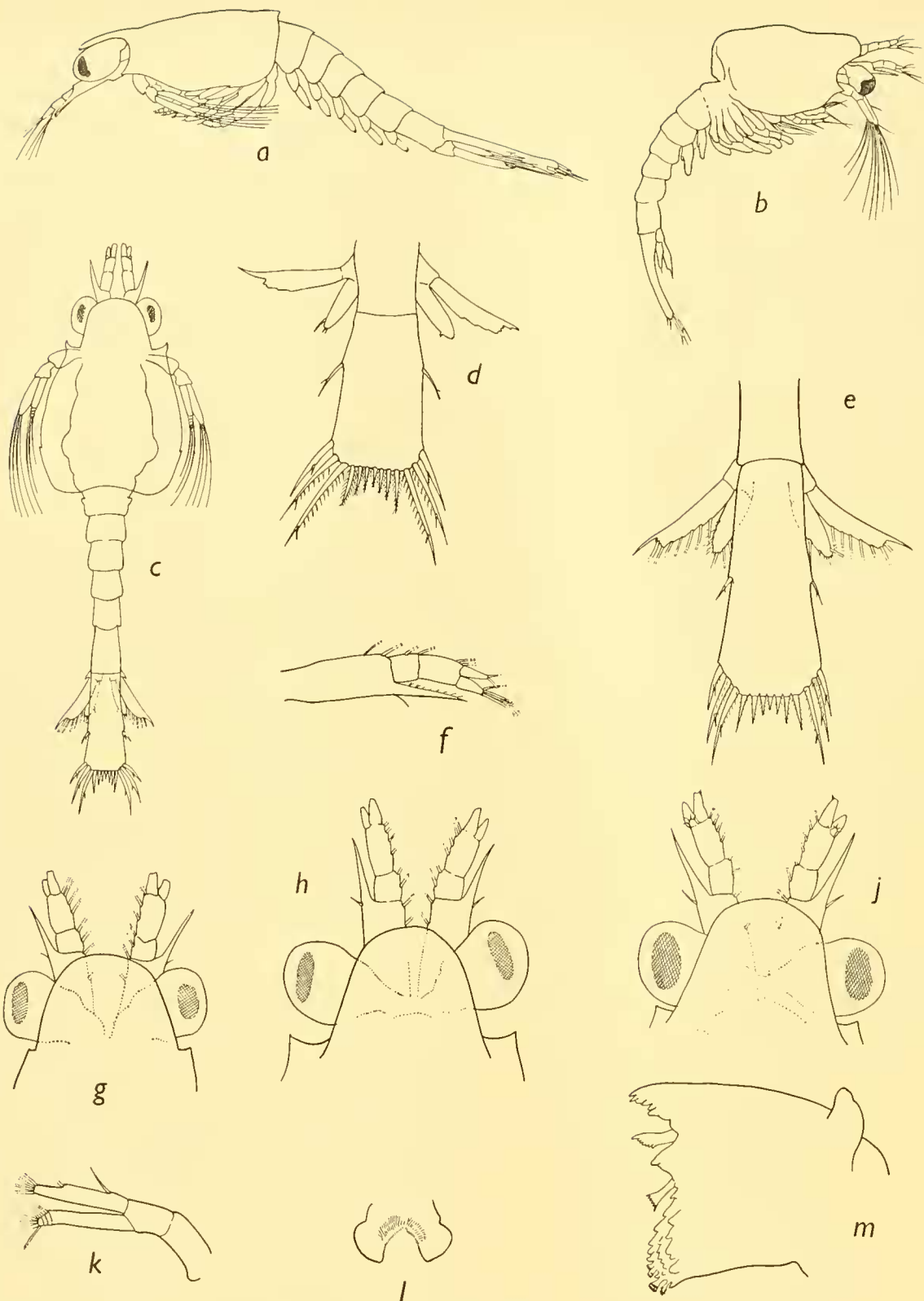


Fig. 15. First Furcilia.

- a, lateral aspect of larva with 5 non-setose pleopods ($\times 14$);
 b, lateral aspect of larva with 2 non-setose pleopods, carapace distorted ($\times 14$);
 c, dorsal aspect of larva with 5 non-setose pleopods ($\times 14$);
 d, uropods and telson of larva with 2 non-setose pleopods ($\times 35$);
 e, uropods and telson of larva with 5 non-setose pleopods ($\times 35$);
 f, antennula of larva with 2 non-setose pleopods ($\times 35$);
 g, rostrum and antennule of larva with 3 non-setose pleopods ($\times 35$);
 h, rostrum and antennule of larva with 4 non-setose pleopods ($\times 35$);
 i, rostrum and antennule of larva with 5 non-setose pleopods ($\times 35$);
 j, rostrum and antennule of larva with 4 non-setose pleopods ($\times 35$);
 k, antenna of larva with 4 non-setose pleopods ($\times 35$);
 l, labrum ($\times 35$);
 m, mandible ($\times 35$).

Table XXIX. Occurrence of First Furcilia

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
(a) No pleopods						
WS 527	30. iii. 30	250-100	8	2	3.50	3.50
(c) 2 non-setose pleopods						
WS 527	30. iii. 30	250-100	4	1	3.88	3.88
(d) 3 non-setose pleopods						
321	30. i. 30	100-50	1	1	4.50	4.50
635	7. iii. 31	50-0	2	2	4.08	4.08
636	8. iii. 31	500-250	2	2	4.13-4.25	4.19
854	20. iv. 32	119-0	3	3	4.42-4.63	4.54
WS 527	30. iii. 30	250-100	8	2	3.79-3.83	3.81
			16	10	3.79-4.63	4.23
(e) 4 non-setose pleopods						
171	25. ii. 27	250-100	1	—	—	—
194	25. ii. 27	500-250	2	1	4.88	4.88
197	3. iv. 27	1000-750	2	2	4.75-5.42	5.11
319	29-30. i. 30	1000-750	1	1	4.88	4.88
320	30. i. 30	500-250	5	5	4.46-5.00	4.77
323	31. i. 30	500-250	5	5	4.33-4.83	4.58
324	1. ii. 30	500-250	1	1	4.54	4.54
332	2-3. ii. 30	250-100	1	1	4.92	4.92
358	11. ii. 30	50-0	2	2	4.79-5.00	4.90
361	25. ii. 30	250-100	2	1	4.67	4.67
362	25. ii. 30	250-100	4	4	4.63-4.83	4.72
368	8. iii. 30	100-50	2	2	5.29-5.46	5.36
		250-100	11	11	4.79-5.50	5.06
		500-250	2	2	5.13-5.17	5.15
369	9. iii. 30	50-0	3	3	4.96-5.63	5.36
		250-100	11	11	4.92-5.63	5.35
383	14. iv. 30	100-50	1	1	4.17	4.17
624	21-22. ii. 31	50-0	4	1	5.17	5.17
635	7. iii. 31	50-0	2	2	4.17-4.42	4.30
		100-50	2	2	4.38-4.54	4.46
		250-100	1	1	4.50	4.50
853	19. iv. 32	119-0	2	2	5.25-5.46	5.36
854	20. iv. 32	119-0	1	1	4.92	4.92
855	20. iv. 32	125-0	5	1	4.71	4.71
861	27. iv. 32	109-0	7	7	4.25-4.79	4.72
WS 201	22. iv. 28	50-0	2	2	5.00-5.33	5.17
		100-50	1	1	4.83	4.83
		250-100	1	1	5.17	5.17
WS 202	23. iv. 28	100-50	1	1	4.83	4.83
WS 527	30. iii. 30	250-100	36	9	4.04-4.83	4.37
			121	84	4.04-5.63	4.87

Table XXIX (cont.)

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
(f) 5 non-setose pleopods						
169	22. ii. 27	500-250	3	3	5.42-5.79	5.54
193	28. iii. 27	500-250	25	21	5.42-6.17	5.90
		750-500	1	1	5.42	5.42
194	28. iii. 27	100-50	3	3	5.08-5.13	5.10
		250-100	10	9	4.75-5.27	5.01
198	3. iv. 27	50-0	4	4	5.21-5.88	5.53
202	5. iv. 27	50-0	3	3	5.25-5.75	5.54
203	5. iv. 27	100-50	1	1	5.21	5.21
205	6. iv. 27	215-100	1	1	6.00	6.00
303	21. i. 30	500-250	7	7	4.92-5.38	5.09
304	21. i. 30	500-250	4	4	4.96-5.33	5.15
305	21-22. i. 30	100-50	1	1	5.33	5.33
312	24-25. i. 30	220-100	1	1	5.08	5.08
313	25. i. 30	250-100	2	2	5.21-5.42	5.32
319	29-30. i. 30	50-0	10	2	4.58-5.00	4.79
		100-50	1	1	4.83	4.83
		250-100	1	1	4.79	4.79
320	30. i. 30	250-100	4	4	4.96-5.04	5.00
321	30-31. i. 30	100-50	1	1	5.17	5.17
323	31. i. 30	500-250	1	1	5.21	5.21
335	4-5. ii. 30	50-0	1	1	5.08	5.08
342	7. ii. 30	500-250	1	1	5.75	5.75
343	7. ii. 30	250-100	1	1	5.25	5.25
344	7-8. ii. 30	100-50	4	4	5.25-5.54	5.43
356	10. ii. 30	250-100	7	7	5.33-5.92	5.70
360	24. ii. 30	100-50	1	1	5.04	5.04
361	25. ii. 30	50-0	3	3	4.88-5.08	4.99
		100-50	3	3	4.83-5.58	5.25
		250-100	148	50	4.88-5.79	5.26
362	25. ii. 30	50-0	55	50	4.71-5.92	5.22
		250-100	35	35	4.67-5.79	5.05
365	2. iii. 30	50-0	10	10	5.79-6.50	6.09
		100-50	1	1	5.71	5.71
		250-100	129	50	5.33-6.33	5.78
		500-250	2	2	5.63	5.63
368	8. iii. 30	50-0	3	2	5.00-5.67	5.34
		100-50	4	4	5.25-5.38	5.31
		250-100	15	15	5.00-5.83	5.47
369	9. iii. 30	250-100	12	12	5.33-5.92	5.58
383	14. iv. 30	100-50	5	5	4.92-5.13	4.99
		250-100	132	33	5.04-5.71	5.40
635	7. iii. 31	50-0	4	3	4.79-5.00	4.90
855	20. iv. 32	125-0	16	16	5.04-6.04	5.45
		125-0	110	20	5.00-5.75	5.30
861	27. iv. 32	109-0	6	6	4.71-4.96	4.83
		270-138	2	2	4.75-4.88	4.82
WS 197	17. iv. 28	250-100	1	1	5.00	5.00
		500-250	1	1	4.75	4.75
WS 198	19. iv. 28	500-250	5	5	5.17-5.42	5.28
WS 199	20. iv. 28	500-250	31	29	5.04-5.75	5.44
WS 200	21. iv. 28	500-250	79	50	5.42-5.92	5.64
WS 201	22. iv. 28	50-0	6	4	5.42-5.92	5.70
		100-50	1	1	5.63	5.63
		250-100	2	2	5.42-5.50	5.46
WS 202	23. iv. 28	250-100	1	1	5.13	5.13
WS 527	30. iii. 30	250-100	20	5	4.33-4.83	4.55
			951	507	4.33-6.50	5.40

The uropods do not reach to the lateral telson spines even in the largest larvae. They consist of a basal segment and two distal plates which are furnished with long setae; these latter are more numerous in larger than in smaller larvae.

ANTENNULE. The antennules, as in the 3rd Calyptopis, are essentially made up of three peduncular segments and an outer and inner flagellar segment (Figs. 15 *f, g, h, j*). There is an increase in the number of sensory filaments on the outer flagellum in the larger larvae compared with the smaller ones in this group and with the 3rd Calyptopis. There are three filaments, one near the base on the inner margin and two situated terminally. Besides these sensory filaments there are three or four long bristles on each flagellum terminally. In the larger larvae there is also at the distal margin of the distal peduncular segment a rounded protrusion immediately dorsal to the outer flagellum, which is armed with four small curved spines. The number of bristles on the inner margins of the peduncular segments has increased compared with the 3rd Calyptopis. The large spinous forward projection of the basal peduncular segment extends beyond the distal margin of the distal peduncular segment.

ANTENNA, MANDIBLE and LABRUM. These are essentially as in the earlier larval stages (Fig. 15 *k, l, m*).

FIRST MAXILLA. The general structure is as in the 3rd Calyptopis, but there are certain differences in detail accompanying increase of size. Thus the outer masticatory lobe has seven spines instead of five on the inner margin, and there may be an additional bristle, seen in the larva with five pairs of non-setose pleopods, situated a little distant from the inner margin on the surface of the lobe. The inner masticatory lobe has eight spines compared with seven in the 3rd Calyptopis. The palp of this appendage is more or less distinctly segmented into two, having three spines on the terminal segment and two on the inner margin of the proximal.

SECOND MAXILLA. The 2nd maxillae are as in the 2nd Calyptopis stage with five lateral lobes bearing many setae and a terminal lobe with three setae.

FIRST THORACIC LIMB. The 1st thoracic limb is essentially as in the Calyptopis stages. One is figured for comparison of size with the succeeding limbs (Fig. 16 *d*).

THORACIC LIMBS II–VI. Unlike the 1st limb the remaining thoracic limbs show a distinct advance in development in this stage compared with the 3rd Calyptopis. They have increased greatly in length, so that they are generally as long as, or slightly longer than, the 1st thoracic. In the larvae examined an indication is given of the irregularity in the development of appendages in individual larvae. Thus the larva with only two pairs of pleopods has the thoracic limbs (Fig. 16 *a*) rather more advanced than the larva with three pairs of pleopods (Fig. 16 *b*). This is probably exceptional, and in the normal course one would expect to find the longer and more developed thoracic appendages occurring in larvae with the larger number of pleopods. The segmentation of the endopod is more distinct in larvae with four or five pleopods, so that whereas in the smaller ones the anterior limbs show only the first signs of incipient segmentation and the posterior ones none at all, in the larva with five pleopods (Fig. 16 *d*) the anterior limbs are five-segmented and thoracic limb VI has three segments. The segmentation is difficult to

distinguish in preserved material, and up to this point in development it is not possible to make out the articulation of either endopod or exopod with the basal portion of the limb. Another feature which tends to give a confused idea of the number of segments in

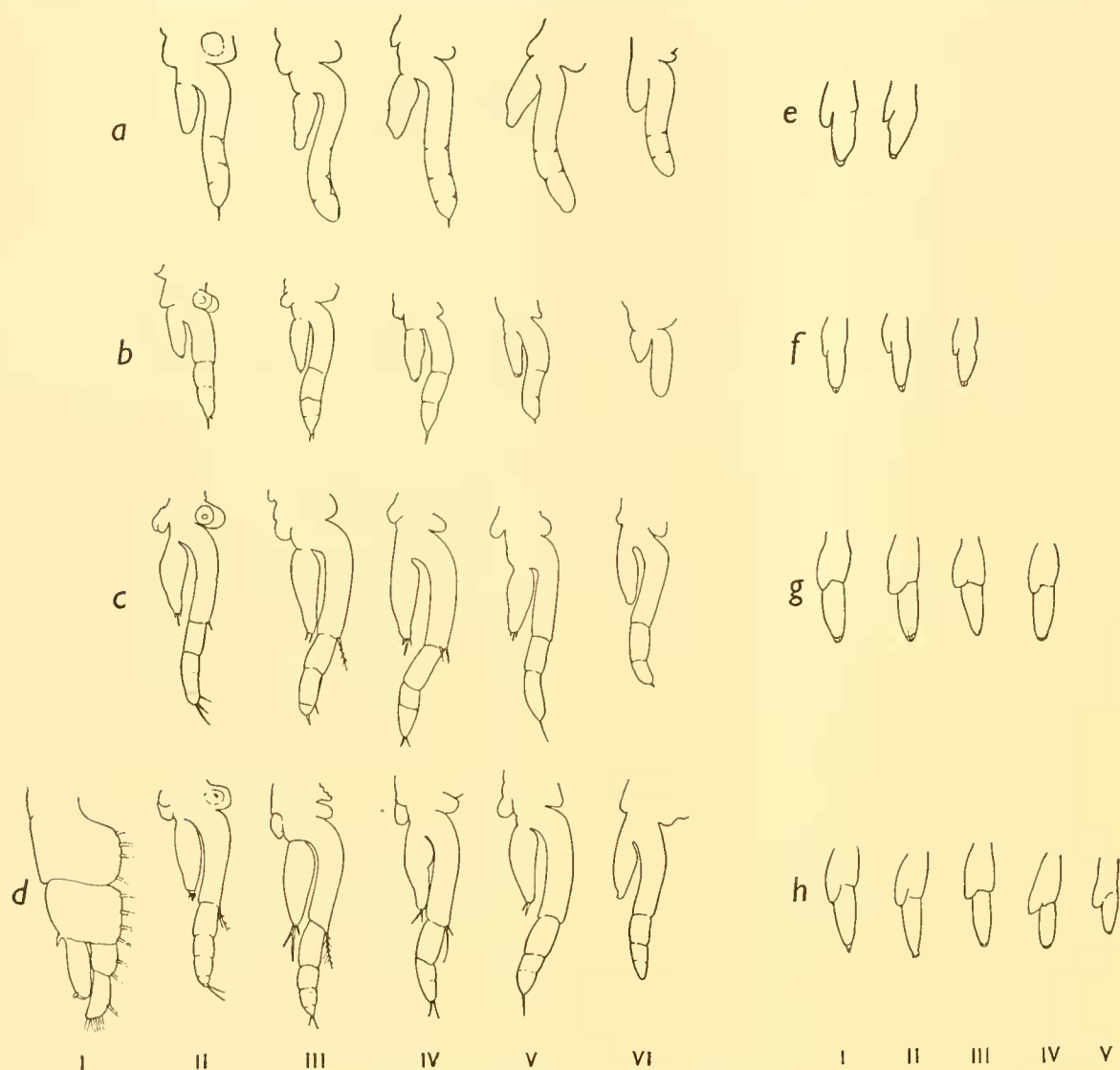


Fig. 16. First Furcilia (continued).

- a*, thoracic limbs II-VI of larva with 2 non-setose pleopods ($\times 35$);
b, thoracic limbs II-VI of larva with 3 non-setose pleopods ($\times 35$);
c, thoracic limbs II-VI of larva with 4 non-setose pleopods ($\times 35$);
d, thoracic limbs I-VI of larva with 5 non-setose pleopods ($\times 35$);
e, pleopods I and II of larva with 2 non-setose pleopods ($\times 35$);
f, pleopods I-III of larva with 3 non-setose pleopods ($\times 35$);
g, pleopods I-IV of larva with 4 non-setose pleopods ($\times 35$);
h, pleopods I-V of larva with 5 non-setose pleopods ($\times 35$).

a limb is that, presumably just prior to moulting, the segmentation of the limb in the following stage is sometimes apparent through the existing integument, and when the joint in the existing integument does not coincide with that of the following stage the

limb has the appearance of having nearly twice as many segments as it actually possesses. The limbs at this stage show a decrease in size and development from in front backwards. There is also an increase in the number of setae in the larvae having the greater number of pleopods, so that instead of two small setae terminally on the endopod of Th. II and III and one seta on Th. IV and V, as in the larvae with three pairs of non-setose pleopods, there are in the larva with five pairs of pleopods on the endopods of Th. II, III and IV two terminal setae and one or two lateral setae and on the endopod of Th. V one terminal seta. The exopods, with the exception of Th. VI, also bear two or three setae at their tips in the larva with five pairs of pleopods. The exopods themselves in the five-pleopod larva show an advance in development from the small larvae in this group, in that they have begun to lose the "sausage shape" and have commenced to show the first signs of the form found in the adult animal.

GILLS. It is in this stage that the gills begin to be obvious on the thoracic limbs. In the larva with three pairs of pleopods they are distinguishable as ill-defined saccular processes on the external margin of the limbs Th. II-V. The gill on Th. VI cannot yet be seen. In the larva with five pairs of pleopods the gills of Th. II, III and IV are slightly bilobed; in Th. V and VI they are simple. Fig. 16 *a-d* shows the gills *in situ*; the bilobed condition is not always obvious when the limb to which the gill is attached is examined dorso-ventrally. There is no sign of a gill on the 1st thoracic appendage of any of the larvae examined.

PLEOPODS. This stage includes, as stated above, larvae having up to five pairs of non-setose pleopods. In the larva having the smallest number, namely two pairs, the limb is distinctly bilobed, having the external lobe or exopod much longer than the internal (Fig. 16*e*). In the first pair of limbs there is already a constriction about the middle of the limb where the exopod merges into the protopodal portion. No such constriction is evident in the endopod nor in either the exopod or endopod of the following pair. In the larva with three pairs of pleopods (Fig. 16*f*) all three pairs are similar to the first pair in the previous larva. There is, however, a decrease in size from in front backwards. In the larvae with four and five pairs of pleopods (Fig. 16*g, h*) the constriction separating exopod from protopodite is well defined and clearly segmented. The endopod still merges into the protopodite.

Within the integument of these non-setose pleopods there can be distinguished developing setae, and in some the tip of the pleopod is drawn out into small digitiform processes. The importance of the setae within the integument is discussed in another section (p. 38). Occasionally larvae are found in which the pleopods of the last pair are very dissimilar to those that precede them. They are much smaller pear-shaped buds without any constriction at the middle. This form of limb does not show the rudiments of setae within the integument. Infrequently also larvae are found in which, in the last pair of pleopods, the one is more developed than the other.

LUMINOUS ORGANS. The luminous organ on the ocular peduncle is distinguishable as a fascicle of fibres situated ventrally behind the visual part of the eye. The organ at the base of the limb Th. II is present; that of Th. VII is not yet apparent, nor are any of the unpaired abdominal ones to be seen.

DISCOVERY REPORTS
SECOND FURCILIA

Included in this group are the following larvae in advance of the Furcilia stage just described:

(a)	With 3 pairs of pleopods: 2 setose, 1 non-setose.
(b)	" 4 " " 1 " 3 "
(c)	" 4 " " 2 " 2 "
(d)	" 4 " " 3 " 1 "
(e)	" 4 " " all setose.
(f)	" 5 " " 2 setose, 3 non-setose.
(g)	" 5 " " 3 " 2 "
(h)	" 5 " " 4 " 1 "
(j)	" 5 " " all setose and having the spines of the telson unaltered.

The above combinations of setose and non-setose pleopods actually occur in the samples examined. It is possible, however, that other variations may be found, for instance, five pleopods of which one pair is setose and four pairs non-setose.

In Table XXX the frequency of occurrence of these larvae with respect to the number of stations and the number of individuals is given. The average lengths are stated in the same manner as in the previous Furcilia stage. For the 2nd Furcilia the average length is 6.11 mm. and the range between 3.96 and 7.92 mm.

The description of this stage is based chiefly on detailed examination of larvae of the forms (f), (g), (h) and (j) in the list given above. The larva having the (f) form of pleopod development was of small size with the fifth pair of legs not nearly so advanced as in the larva having five pairs of non-setose pleopods described in the previous Furcilia stage. In the (f) larva the pleopods of the fifth pair were small hardly distinguishable buds, yet the first two pairs were definitely setose. The degree of development of the thoracic limbs indicated that the larva was certainly *E. superba*.

In this stage the rostrum is still evenly rounded without any median spine and does not reach nearly to the distal margin of the basal peduncular segment of the antennule (Fig. 17 b, c, d, e). There is a small lateral denticle on the postero-lateral corner of the carapace (Fig. 17 a). The telson is seven-spined terminally and has the postero-lateral spines unaltered (Fig. 18 a); that is to say, the innermost postero-lateral has not the

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- a, lateral aspect of larva with all pleopods setose ($\times 12$);
b, dorsal aspect of larva with all pleopods setose ($\times 14$);
c, antennule and rostrum of larva with 3 setose, 2 non-setose pleopods ($\times 35$);
d, antennule and rostrum of larva with 4 setose, 1 non-setose pleopods ($\times 35$);
e, antennule and rostrum of larva with 5 setose pleopods ($\times 35$);
f, uropod and telson of larva with 3 setose, 2 non-setose pleopods ($\times 35$);
g, uropod and telson of larva with 4 setose, 1 non-setose pleopods ($\times 35$);
h, uropod and telson of larva with 5 setose pleopods ($\times 35$);
j, antenna of larva with 5 setose pleopods ($\times 35$);
k, mandibular palps of larva with 5 setose pleopods ($\times 83$);
l, first maxilla of larva with 5 setose pleopods, plumose condition of exognath bristles and spinules on terminal bristles of palp not indicated ($\times 165$);
m, second maxilla of larva with 5 setose pleopods ($\times 35$).

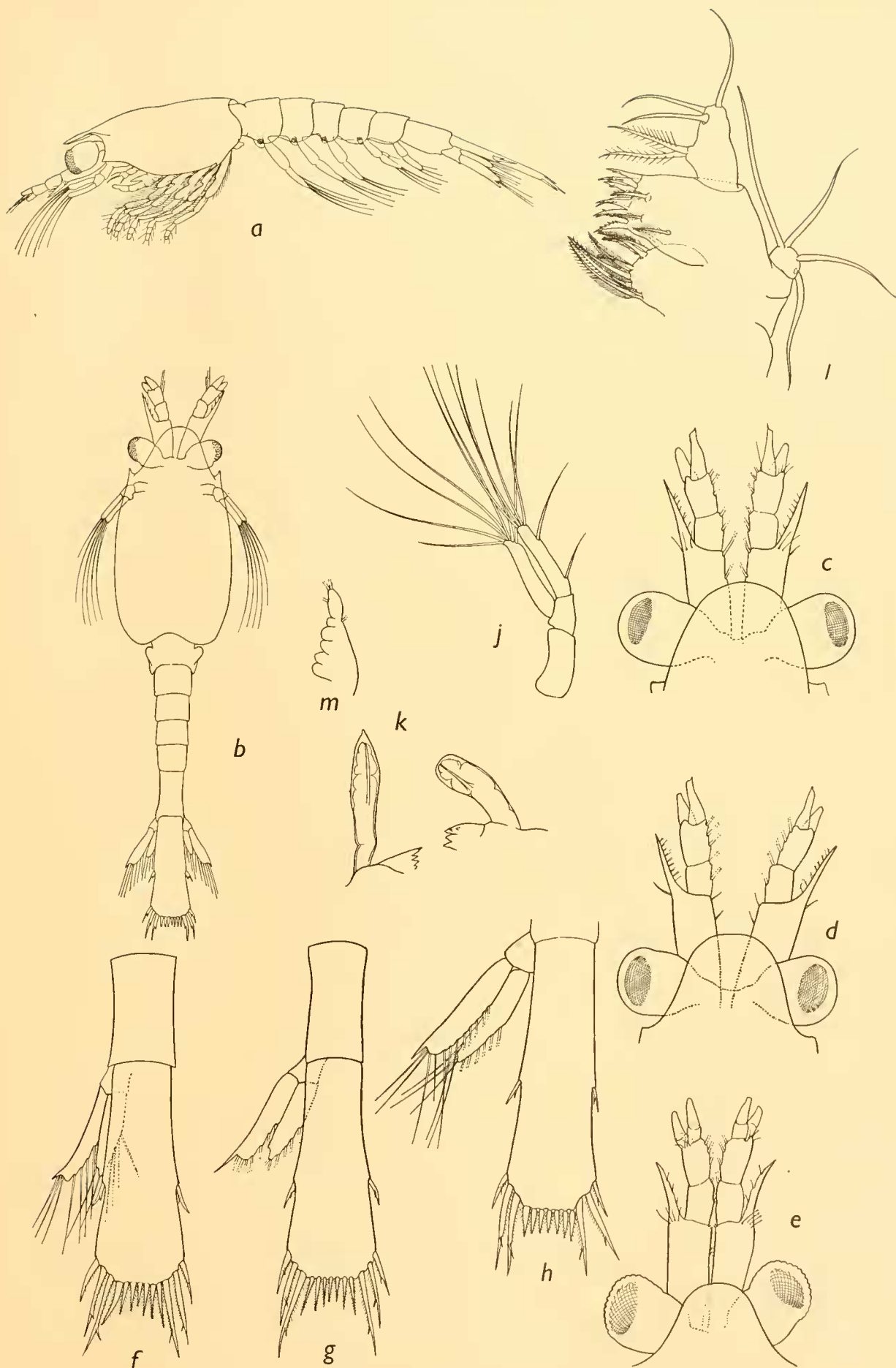


Fig. 17. Second Furcilia.

Table XXX. Occurrence of *Second Furcilia*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
(a) 3 pleopods: 2 setose, 1 non-setose						
WS 527	30. iii. 30	250-100	8	2	3.96-4.04	4.00
(b) 4 pleopods: 1 setose, 3 non-setose						
WS 527	30. iii. 30	250-100	4	1	4.58	4.58
(c) 4 pleopods: 2 setose, 2 non-setose						
WS 527	30. iii. 30	250-100	4	1	4.54	4.54
(d) 4 pleopods: 3 setose, 1 non-setose						
WS 527	30. iii. 30	250-100	4	1	4.50	4.50
(e) 4 pleopods: all setose						
WS 527	30. iii. 30	250-100	32	8	4.63-5.29	4.86
WS 529	2. iv. 30	500-250	2	2	4.58-5.00	4.79
			34	10	4.58-5.29	4.84
(f) 5 pleopods: 2 setose, 3 non-setose¹						
661	2. iv. 31	360-0	1	1	4.79	4.79
(g) 5 pleopods: 3 setose, 2 non-setose						
WS 527	30. iii. 30	100-50	2	1	4.38	4.38
		250-100	4	1	5.25	5.25
			6	2	4.38-5.25	4.82
(h) 5 pleopods: 4 setose, 1 non-setose						
198	3. iv. 27	50-0	2	2	6.63-6.84	6.74
375	21. iii. 30	500-250	3	3	5.21-5.79	5.51
639	9. iii. 31	50-0	1	1	5.92	5.92
853	19. iv. 32	119-0	1	1	5.96	5.96
861	27. iv. 32	109-0	3	3	5.00-5.88	5.53
887	27. v. 32	120-0	2	2	5.08-5.33	5.21
WS 201	22. iv. 28	500-250	1	1	6.00	6.00
WS 202	23. iv. 28	500-250	2	1	5.50	5.50
WS 527	30. iii. 30	100-50	4	4	5.04-5.13	5.10
		250-100	116	29	4.58-5.58	5.06
WS 529	2. iv. 30	750-500	1	1	5.33	5.33
			137	49	4.58-6.84	5.47

¹ This pleopod arrangement was found in one larva only, taken from a young Fish Trawl net and not from a 70-cm. vertical net.

Table XXX (cont.)

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
(j) 5 setose pleopods; spines on telson unaltered						
199	3. iv. 27	500-250	5	5	6.33-6.83	6.62
200	4. iv. 27	300-250	1	1	6.83	6.83
201	5. iv. 27	50-0	2	2	6.46-7.00	6.73
		250-100	1	1	6.67	6.67
203	5. iv. 27	250-100	1	1	5.33	5.33
204	6. iv. 27	500-250	8	5	5.92-7.00	6.58
302	21. i. 30	250-100	1	1	6.92	6.92
303	21. i. 30	500-250	2	2	6.08-6.25	6.17
305	21-22. i. 30	250-100	1	1	6.46	6.46
319	29-30. i. 30	100-50	2	2	5.63-5.75	5.69
323	31. i. 30	500-250	2	2	5.63-6.00	5.82
335	4-5. ii. 30	50-0	1	1	6.00	6.00
338	5. ii. 30	225-100	1	1	6.08	6.08
342	7. ii. 30	500-250	3	3	6.17-6.83	6.61
343	7. ii. 30	250-100	1	1	6.46	6.46
353	9. ii. 30	250-100	1	1	6.63	6.63
354	9. ii. 30	500-250	1	1	6.75	6.75
360	24. ii. 30	50-0	1	1	5.83	5.83
361	25. ii. 30	50-0	1	1	5.75	5.75
		100-50	3	3	5.96-6.67	6.24
		250-100	140	50	5.83-7.33	6.62
362	25. ii. 30	50-0	7	7	6.46-7.29	6.75
		250-100	2	2	6.42-6.79	6.61
365	2. iii. 30	50-0	2	2	7.25-7.42	7.34
		250-100	2	2	7.17-7.29	7.23
368	8. iii. 30	50-0	1	1	7.00	7.00
		100-50	1	1	6.50	6.50
		250-100	12	12	6.25-7.08	6.56
369	9. iii. 30	50-0	1	1	6.92	6.92
		250-100	8	8	6.54-6.92	6.70
372	18. iii. 30	50-0	7	7	5.58-6.04	5.81
		100-50	3	3	5.63-5.92	5.74
373	19. iii. 30	50-0	1	1	6.17	6.17
374	20. iii. 30	50-0	1	1	5.67	5.67
375	21. iii. 30	500-250	8	8	5.21-6.67	5.91
635	7. iii. 31	50-0	1	1	5.92	5.92
855	20. iv. 32	125-0	8	8	6.54-6.96	6.75
		125-0	5	1	6.25	6.25
861	27. iv. 32	109-0	61	61	5.00-6.71	5.88
		270-138	44	44	5.25-7.00	6.06
862	28. iv. 32	102-0	6	6	5.63-6.38	5.99
887	27. v. 32	120-0	9	9	5.79-6.75	6.19
		86-0	19	19	5.92-6.71	6.30
		5-0	6	6	6.17-6.83	6.38
WS 199	20. iv. 28	500-250	17	15	6.29-7.21	6.74
WS 200	21. iv. 28	500-250	49	42	6.33-7.92	6.87
		750-500	3	2	6.54-7.17	6.86
WS 201	22. iv. 28	50-0	2	2	6.13-6.42	6.28
		250-100	1	1	5.42	5.42
WS 202	23. iv. 28	100-50	4	2	5.00-6.00	5.50
		250-100	2	2	5.29-6.46	5.88
WS 524	2. iii. 30	500-250	2	2	5.92-6.00	5.96
WS 527	30. iii. 30	50-0	8	2	5.21-5.75	5.48
		100-50	10	10	5.08-6.21	5.55
		250-100	224	56	4.63-6.33	5.59
WS 529	2. iv. 30	500-250	3	3	5.63-6.21	5.86
		750-500	3	3	5.63-6.13	5.95
			722	439	4.63-7.92	6.22

basal portion greatly broadened as in subsequent stages. The telson is from $2\frac{1}{2}$ to 3 times as long as its greatest width. The uropods extend to, or a very little way beyond, the lateral spines of the telson. The setae on the margins of the exopod and endopod are increased in number—as many as twelve being found on the outer ramus and ten on the inner ramus (Fig. 17 *f, g, h*).

ANTENNULE. The antennules are not altered in general structure, consisting as they do of three peduncular segments with two flagella distally (Fig. 17 *c, d, e*). The latter are unsegmented except in the largest larvae included in this stage (Fig. 17 *e*); in these the flagella may show faint indications of division into a proximal and distal segment. The sensory filaments of the flagella are situated away from the tip of the inner side of the outer flagellum. The forward spinous lateral projection of the basal peduncular segment does not extend as far as the distal margin of the distal peduncular segment. As in the previous stage it is armed with spinules along the inner margin. There are also several spinules around the base of this spine on the basal peduncular segment. The flagella are shorter than the combined lengths of the two distal peduncular segments.

ANTENNA. The antennae are still unchanged (Fig. 17 *j*).

MANDIBLE. In this stage the first signs of the changes in the mandible leading to the adult form become noticeable. The palp tends to be more elongate in the larger larvae; for example, in the larva with all pleopods setose it is an unsegmented digitiform process. The specimen figured shows segmentation within the integument and a long spine embedded in the soft tissues (Fig. 17 *k*). In the smaller larvae the palp is a short conical process similar to that found in earlier stages.

There are alterations in the tooth portion of the mandible which are most pronounced in the largest larvae. Sars (1885), referring to *Nyctiphanes australis* (p. 153), says in his description of the *Calyptopis* mandible:

The armature of the cutting edges is well developed though somewhat dissimilar to that in the adult animal, resembling rather the armature found in some Mysidae. As it occurs in the latter the anterior part is divided into several strong, and very closely arranged, teeth forming together two partly superposed portions which in the two mandibles exhibit a somewhat different shape. Between this dentate part and the molar protuberance occurs a short dentiform projection, and at the base of the latter is affixed on both mandibles a very peculiar narrow plate expanded at the extremity and having the apical edge finely denticulate. This plate, wanting entirely in the adult animal, would appear to be movably connected with the mandible since it is very easily disengaged.

That part of the incisor process which could in the earlier stages be recognized as a pedunculated projection bearing small denticulations on the inferior border distally becomes reduced in size in the smaller larvae belonging to this stage (Fig. 18 *b*) and in the larger disappears altogether. The lacinia mobilis also is less conspicuous in the larger larvae of this furcilia stage.

FIRST MAXILLA. The general structure is as in 3rd *Calyptopis*, that is, consisting of a palp, outer and inner masticatory lobe and an exognath (Fig. 17 *b*). The advance in development from the previous stage is evident in the palp, which is now composed of a single segment, and in the masticatory lobes, where an increase in the number of spines has taken place. In the larva with three pairs of setose pleopods the outer lobe

has eight marginal spines and one submarginal; the inner lobe spine number is unchanged. In the larva with four pairs of setose pleopods there are at least nine marginal spines on the outer masticatory lobe and a similar number on the inner. In the larva with all pleopods setose there are only eight marginal bristles on the outer masticatory lobe, but there are three submarginal bristles; on the inner there are nine marginal bristles.

SECOND MAXILLA. The 2nd maxillae are as in the previous stage (Fig. 17 *m*).

FIRST THORACIC LIMB. In the smaller larvae in this group the 1st thoracic appendage (Th. I) is as in previous stages, but in the larger larvae there is an advance in development marked by the elongation of the inner ramus and by its further segmentation into more than two. The endopod is never more than about twice as long as the exopod (Figs. 18 *c, d, e*).

THORACIC LIMBS II–VII. The thoracic limbs II–VI are much larger than Th. I. Also in this stage the flexion of the limbs which is found in adults becomes noticeable; that is to say, in the endopod the two proximal segments are directed forwards and downwards, and the three distal segments reflexed so that they point downwards and backwards. Of the larvae examined that having three pairs of setose pleopods has the thoracic limbs IV–VI of the form shown in Fig. 18 *c*. The 2nd thoracic limb endopod is longer than the 1st but shorter than Th. III or Th. IV which are the most developed of these appendages. The fifth limb endopod is indistinctly five-segmented, and the sixth, which is much the shortest, is still “sausage-shaped” and not so densely setose as the more anterior limbs. The setae on the endopods, which are chiefly situated along the inner margin of the limb, are of two kinds—short plumose setae projecting inwards, and longer plumose setae directed anteriorly. This applies to the proximal segments of the endopod; the distal three segments are not so heavily setose. The exopods, with the exception of the VIth, are more lamellar in form than in the previous stage; setae are present on the outer and inner margins as well as on the tips. In Th. III, IV and V the exopod shows the beginning of differentiation into two portions, a distal natatory part and, proximally, a strongly muscular portion. The distinction is noticeable in the outer margin by the formation of a shoulder-like projection about the middle of this edge, and on the inner margin by a curved projection near the base.

In the larvae with four pairs of setose pleopods there is an increase in the number of setae on exopods and endopods (Fig. 18 *d*). The endopod of Th. VI is segmented into four and the exopod is more lamellar in form than in the smaller larva with three pairs of pleopods. Situated behind Th. VI is a very small inconspicuous protrusion—the first rudiment of Th. VII.

In the largest larva—that having five pairs of setose pleopods—the endopods of the limbs II–VI are all distinctly five-segmented and the exopods are clearly divided into two portions, a distal natatory part and a proximal muscular part (Fig. 18 *e*). Setae extend along both the outer and inner margins to the projections on these described above. Setae on the endopod are greatly developed. Fig. 18 *e* shows the inner margin of Th. V to illustrate the arrangement of the two sets of setae found in the two proximal

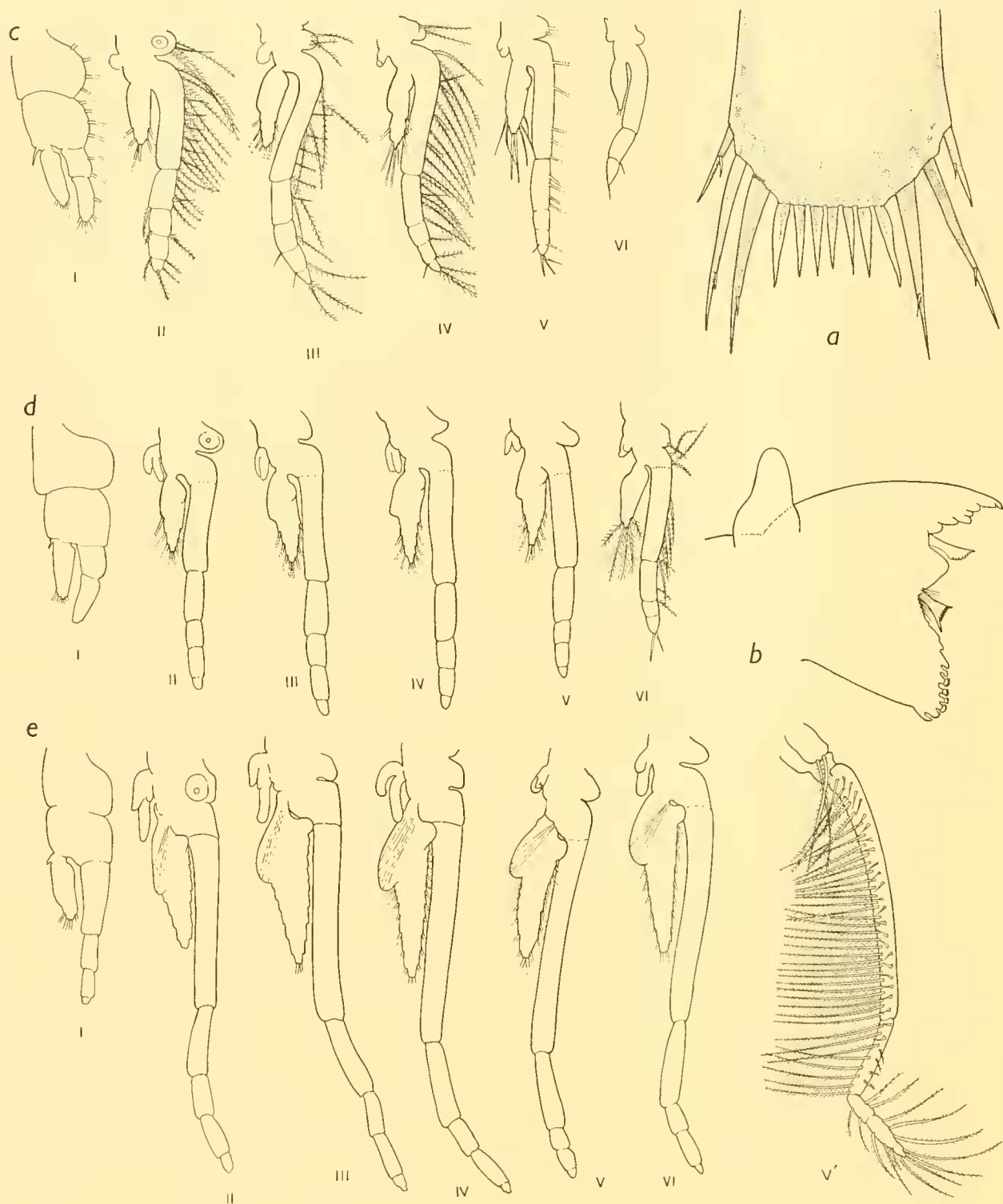


Fig. 18. Second Furcilia (continued).

a, telson of larva with 5 pairs of non-setose pleopods, spinules omitted ($\times 85$);

b, mandible of larva with 3 setose, 2 non-setose pleopods ($\times 165$);

c, thoracic limbs I-VI of larva with 3 setose, 2 non-setose pleopods ($\times 35$);

d, thoracic limbs I-VI of larva with 4 setose, 1 non-setose pleopods, bristles on limbs omitted except on Th. VI ($\times 35$);

e, thoracic limbs I-VI of larva with 5 pairs of non-setose pleopods, bristles omitted except V' lateral view of Th. V, drawn to show inner aspect of limb ($\times 35$).

segments; it also shows the natural flexion of the limb which is typical of thoracic appendages from this stage onward to the adult. Between Th. VI and the first abdominal segment, in the larva having five pairs of setose pleopods, there is a small process on each side, which is flattened antero-posteriorly and is the vestige of Th. VII (Fig. 19 *a*). In this aspect it appears roughly semicircular in outline with a small emargination near the external border. The ill-defined outer lobe is the developing gill, while in the inner part is the luminous organ belonging to this appendage which will develop in the next stage.



Fig. 19. Second Furcilia (continued).

a, lateral view of bases of thoracic limb VI and pleopod I with, between them, thoracic limb VII, *a'* Th.

VII seen from behind ($\times 83$);

b, gills on thoracic limbs II-VI in larva with 4 setose, 1 non-setose pleopods ($\times 83$);

c, gills on thoracic limbs II-VI in larva with 5 setose pleopods ($\times 83$);

d, pleopods I-V in larva with 3 setose, 2 non-setose pleopods ($\times 35$);

e, pleopods I-V in larva with 4 setose, 1 non-setose pleopods ($\times 35$);

f, pleopods I-V in larva with 5 setose pleopods ($\times 35$);

g, appendix interna ($\times 360$);

h, setae within the integument of a non-setose pleopod ($\times 165$).

GILLS. In the smaller larvae included in this stage the gills are at much the same stage of development as in the larva having five pairs of non-setose pleopods, the only advance noted in the larva having three pairs of setose pleopods is that the gill of Th. V is now bilobed. In the larva with four pairs of setose pleopods the branchiae of Th. II-VI are all distinctly bilobed (Fig. 19 *b*). The gills of Th. II-VI in the larva with all pleopods

setose have increased in size and show the beginnings of a third lobe at the base of the inner lobe (Fig. 19 *c*). The gill of Th. VII has already been described in connection with the limb rudiment. There is no sign in this Furcilia stage of a gill on the 1st thoracic limb.

PLEOPODS. The variety of pleopod forms within this stage is indicated in the list at the beginning of this section. The appearance of the pleopods in larvae having respectively three, four and five pairs setose is shown in Fig. 19 *d, e, f*. The non-setose pleopods are typically as in the larger larvae in the preceding stage, that is, having the exopod marked off from the protopodite and the endopod merging into it. Within the integument of the non-setose pleopods there can be distinguished the setae with which the exopod will be furnished when the larva moults (Fig. 19 *h*). The setose pleopods have six to eight setae on the exopod, which is now divided off from the protopodite, and from one to three setae on the endopod. At this stage the appendix interna appears on the inner margin of the endopods of those pleopods which are setose (Fig. 19 *g*). In the smaller larvae it is represented by a small hook-like process on the endopod, whilst in the larva with five setose pleopods a number of these hooks are borne on a digitiform projection from the inner margin of the endopod.

LUMINOUS ORGANS. In addition to those on the ocular peduncle and at the base of Th. II there are the following unpaired luminous organs distinguishable between the pleopods:

The larva having

- 2 setose pleopods and 3 non-setose has luminous organs on abdominal segments 1 and 2.
- 3 setose pleopods and 2 non-setose has luminous organs on abdominal segments 1, 2 and 3.
- 4 setose pleopods and 1 non-setose has luminous organs on abdominal segments 1, 2, 3 and 4.
- 5 setose pleopods has also four abdominal luminous organs.

The development of the luminous organs on the abdominal segments thus coincides with the development of setae on the pleopods.

The luminous organ on Th. VII cannot yet be distinguished.

THIRD FURCILIA

The reasons for recognizing this form of larva as a separate stage are given above on pp. 41-9. The frequency of occurrence of these larvae and their average lengths at different stations are stated in Table XXXI. For all the 3rd Furcilia the average length is 7.32 mm., and the range lies between 5.79 and 8.75 mm.

The two previous Furcilia stages are recognizable by the number and degree of development of the pleopods. In this stage other criteria must be adopted, as the pleopods have reached their full number and are all setose as in the largest larvae of the preceding stage. The most convenient character for this purpose is the form and number of the telson spines; the number is the same as in the earlier Furcilia stages, but the innermost postero-lateral spine, as shown in Fig. 20 *c*, is altered, being greatly widened at the base. Other distinctions in development in this Furcilia stage will be mentioned below.

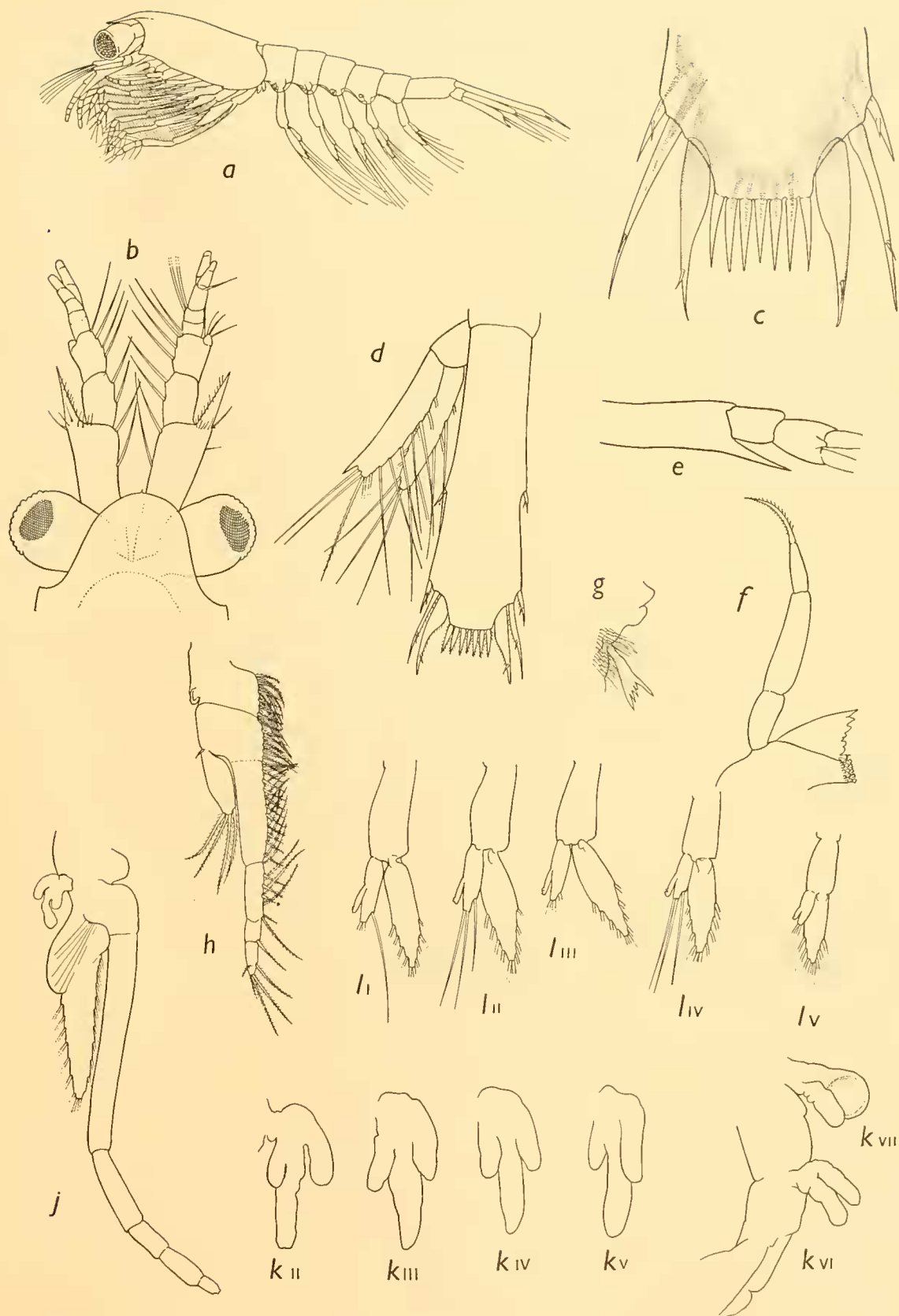


Fig. 20. Third Furcilia.

a, lateral aspect ($\times 9$);

b, rostrum and antennules ($\times 35$);

c, telson, lateral spinules ($\times 85$);

d, uropod and telson ($\times 35$);

e, antennule ($\times 35$);

f, mandible ($\times 83$);

g, lacinia mobilis ($\times 360$);

h, thoracic limb I showing arrangement of bristles ($\times 35$);

j, thoracic limb III ($\times 35$);

k, gills I-VII, base of Th. VI with Br. VI shown entire,
Th. VII consisting of luminous organ and gill ($\times 83$);

l, pleopods I-V ($\times 35$).

Table XXXI. *Occurrence of Third Furcilia*

5-setose pleopods: spines on telson altered

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
194	28. iii. 27	50-0	1	1	7.29	7.29
197	3. iv. 27	100-50	7	7	7.29-8.17	7.70
		1000-750	1	1	8.00	8.00
198	3. iv. 27	50-0	4	3	7.42-8.13	7.74
		100-50	5	4	7.42-7.83	7.64
199	3. iv. 27	50-0	1	1	7.50	7.50
		250-100	1	1	7.58	7.58
		500-250	19	17	7.00-7.92	7.45
		750-500	21	21	6.75-8.00	7.41
200	4. iv. 27	300-250	2	2	7.58-7.71	7.65
201	5. iv. 27	50-0	3	3	7.08-7.58	7.32
203	5. iv. 27	50-0	6	4	7.04-7.79	7.43
		100-50	1	1	8.00	8.00
		250-100	1	1	7.71	7.71
204	6. iv. 27	500-250	13	13	6.92-7.67	7.28
206	6. iv. 27	250-100	1	1	7.00	7.00
304	21. i. 30	500-250	2	2	7.58-7.63	7.61
337	5. ii. 30	250-100	1	1	7.54	7.54
360	24. ii. 30	50-0	1	1	7.38	7.38
361	25. ii. 30	250-100	16	8	8.00-8.75	8.46
362	25. ii. 30	50-0	1	1	8.04	8.04
368	8. iii. 30	250-100	1	1	8.25	8.25
369	9. iii. 30	50-0	1	1	8.08	8.08
		250-100	1	1	8.25	8.25
372	18. iii. 30	50-0	3	3	7.08-7.29	7.11
		100-50	1	1	6.96	6.96
373	19. iii. 30	50-0	1	1	7.58	7.58
374	20. iii. 30	50-0	9	9	6.38-7.58	6.99
		100-50	1	1	7.63	7.63
375	21. iii. 30	50-0	1	1	6.67	6.67
		500-250	10	10	6.25-7.63	6.92
855	20. iv. 32	125-0	2	2	7.58-7.67	7.63
861	27. iv. 32	109-0	29	29	6.67-7.83	7.27
		270-138	28	28	6.71-8.15	7.26
862	28. iv. 32	102-0	3	3	7.04-7.38	7.20
		220-98	1	1	6.71	6.71
887	27. v. 32	120-0	4	4	6.58-6.96	6.75
		86-0	5	5	6.58-8.04	6.96
		5-0	7	7	6.67-7.21	6.87
888	28. v. 32	98-0	23	18	6.92-7.50	7.29
		240-90	1	1	7.13	7.13
WS 199	20. iv. 28	500-250	3	3	7.33-8.04	7.74
WS 200	21. iv. 28	500-250	13	13	7.75-8.50	8.21
WS 201	22. iv. 28	50-0	1	1	7.33	7.33
WS 427	28. iv. 29	50-0	1	1	7.08	7.08
WS 527	30. iii. 30	50-0	12	3	6.75-7.08	6.94
		100-50	1	1	6.58	6.58
		250-100	16	4	5.79-6.79	6.46
WS 529	2. iv. 30	500-250	13	13	6.33-7.42	7.02
		750-500	29	29	5.92-7.67	6.99
			329	289	5.79-8.75	7.32

The carapace is, with minor modifications, as in the previous stage (Fig. 20 *a*). The posterior margin is more concave and the rostrum slightly more elongate (Fig. 20 *b*), but the latter is still rounded anteriorly except for a minute spine which may or may not be present on the apex of the anterior border.

The telson is seven-spined terminally and has the modification (Fig. 20 *c*) of the postero-lateral spine just mentioned. The length of the telson is about $3\frac{1}{3}$ times the width. The uropods extend beyond the lateral spines of the telson and are more setose, having in the specimen figured thirteen setae on the outer ramus and twelve on the inner (Fig. 20 *d*).

ANTENNULE. The flagella of the antennules are multi-articular: in the specimen figured five segments are found (Fig. 20 *b*). They are roughly equal in length to the two distal peduncular segments. The spine on the outer margin of the basal peduncular segment is shorter than in the preceding stage, extending not more than about two-thirds of the length of the distal peduncular segment (Fig. 20 *e*).

ANTENNA. The antennae are still unchanged.

MANDIBLE. The palp (Fig. 20 *f, g*) is three-segmented with a long terminal spine. The variations in form of this appendage in this stage are dealt with in another section (p. 65). The lacinia mobilis is still present with fine hairs surrounding the base.

FIRST MAXILLA. The palp of the 1st maxilla is unsegmented and has two extra bristles on the inner margin, making seven bristles in all. The outer masticatory lobe in the specimen examined has nine marginal and two submarginal bristles. The inner masticatory lobe has ten bristles, five of which are heavily setose and more robust, the remainder slighter, smaller, and only finely plumose. The exognath is unchanged. The divisions separating the 1st and 2nd segments of the protopodite (sympod) cannot be distinguished in this or in earlier stages, although a suggestion of such segmentation was indicated in the 3rd Calyptopis.

SECOND MAXILLA. The 2nd maxillae are unchanged.

FIRST THORACIC LIMB. The endopod of this appendage is definitely five-segmented, armed with numerous bristles and about three times as long as the exopod (Fig. 20 *h*). The joint between the basal segment and the 1st endopod segment is very indistinct in this as in all the other limbs. The exopod is still primitive in form, bearing four bristles distally.

THORACIC LIMBS II–VII. The thoracic appendages II–VI are proportionately more elongate than in the previous stage. The exopods are rather longer in relation to the most proximal segment of the endopod and more setose than in the previous stage. Only Th. III has been figured to show the size compared with Th. I (Fig. 20 *j*). Th. II is still very slightly shorter than Th. III–VI. Th. VII is represented by two portions made up of a branchial lobe externally and a luminous organ internally (Fig. 20 *k*). There is no trace of Th. VIII at this stage.

GILLS. The gill on Th. I is small and inconspicuous. Those on Th. II–V are trilobed, having the central branch longer than the remaining two. The gill of Th. VI is bilobed

with the beginnings of a third at the base of the inner lobe, and that on Th. VII is a single lobed process bearing the luminous organ on the peduncle (Fig. 20 *k*).

PLEOPODS. All the pleopods are setose, proportionately longer than in the preceding stage and have the endopod longer in relation to the exopod (Fig. 20 *l*). The pleopods are more setose, with eight to ten setae on the exopod instead of six to eight as in the largest larvae of the preceding stage. Pleopod V is more nearly similar to the remainder, but the inner ramus is still less developed than the others. The appendix interna is a digitiform process furnished with hooks.

LUMINOUS ORGANS. In addition to the light organs present on the largest larva belonging to the previous stage, the organ of Th. VII can now be distinguished (Fig. 20 *k* *vii*).

Table XXXII records the occurrence of larvae having six terminal spines on the telson. As stated on p. 51 above, larvae with an even number of terminal spines are in their general structure intermediate between those having respectively one more and one fewer telson spines. The infrequency of occurrence of the six spined form compared with those having seven and five shows that the former number must be regarded as a rare abnormality.

Table XXXII. *Occurrence of Furcilia larvae with six terminal spines on the telson*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
197	3. iv. 27	100-50	2	2	8.54-8.92	8.73
374	20. iii. 30	50-0	7	7	6.46-7.54	7.19
375	21. iii. 30	500-250	2	2	6.88-7.08	6.98
862	28. iv. 32	102-0	3	3	7.29-7.63	7.45
WS 527	30. iii. 30	50-0	1	1	7.38	7.38
			15	15	6.46-8.92	7.43

FOURTH FURCILIA

The frequency of occurrence and average lengths of larvae belonging to this stage are stated in Table XXXIII. The average length of all the larvae is 8.01 mm., and the range between 6.67 and 9.92 mm.

The rostrum (Fig. 21 *a*, *b*) is more elongate and narrower than in the previous stage and may have a small denticle at its apex. The lateral denticle is present.

The telson (Fig. 21 *d*) is about four times as long as broad, bearing five terminal spines and three postero-lateral spines. The innermost postero-lateral is more modified than in the previous stage (Fig. 21 *c*); the broadened portion extends much nearer to the tip and the setae are missing from the inner margin proximally. The uropods extend beyond the lateral spines on the telson and may have one or two more setae than in the previous stage.

ANTENNULE. The flagella are multi-articulate and rather longer than the two distal peduncular segments. The spine on the outer margin of the basal peduncular segment extends to about the middle of the distal segment (Fig. 21 *b*). A lateral view of the peduncular segment is shown in Fig. 21 *e*.

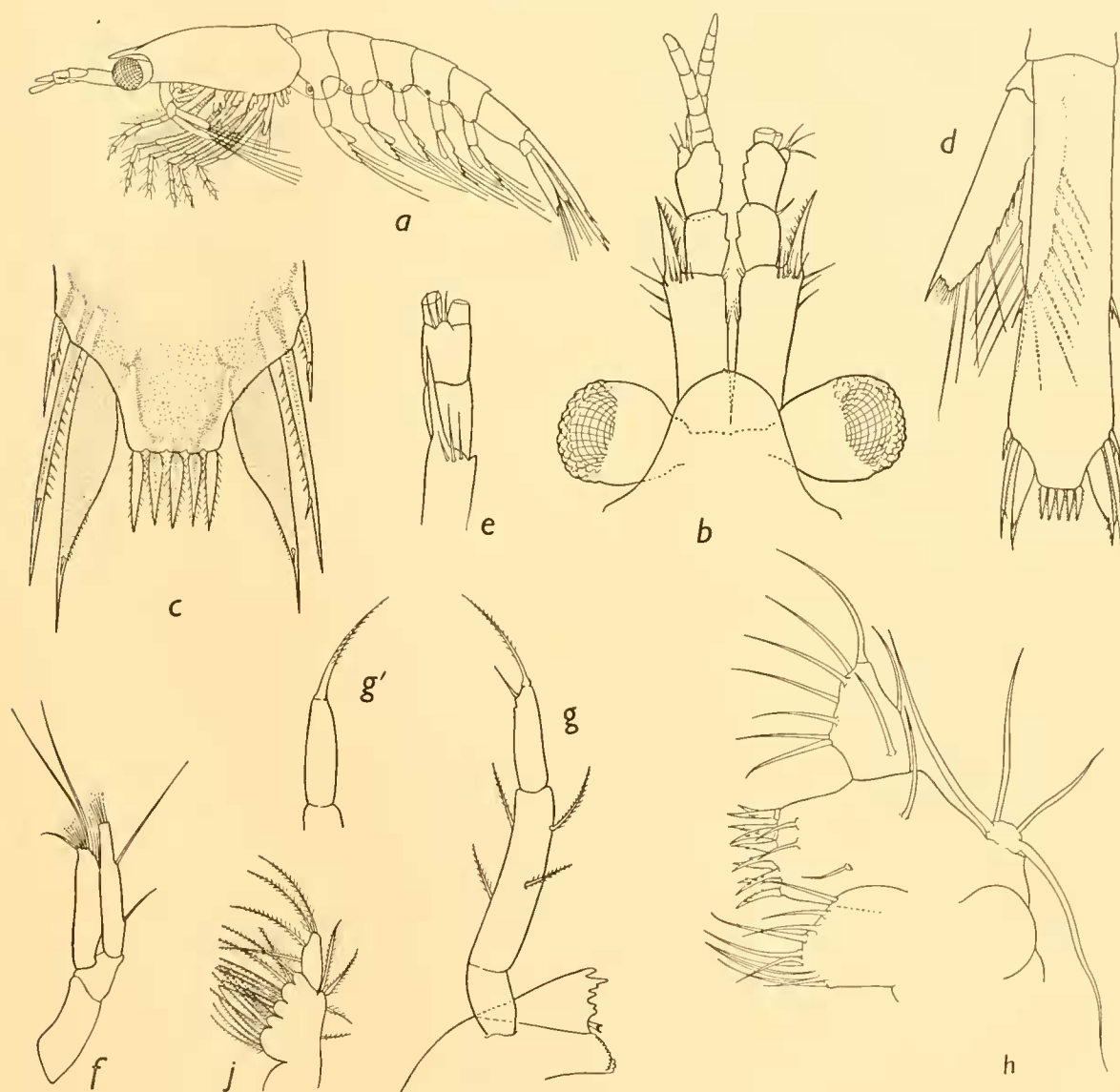


Fig. 21. Fourth Furcilia.

- | | |
|---|---|
| <i>a</i> , lateral aspect ($\times 9$); | <i>f</i> , antenna ($\times 35$); |
| <i>b</i> , rostrum and antennules ($\times 35$); | <i>g</i> , mandible ($\times 83$); <i>g'</i> , tip of palp ($\times 83$); |
| <i>c</i> , telson ($\times 83$); | <i>h</i> , first maxilla, spinules on bristles omitted ($\times 110$); |
| <i>d</i> , uropod and telson ($\times 35$); | <i>j</i> , second maxilla ($\times 35$). |
| <i>e</i> , antennule, lateral view ($\times 35$); | |

ANTENNA. There is only a faint indication in the antennae of differentiation into a scale and flagellum in the specimen figured (Fig. 21 *f*), but the variations in the form of this appendage are dealt with on p. 60. In this specimen the endopod is broader in proportion to its length than in earlier stages, but the number of bristles is unchanged.

Table XXXIII. *Occurrence of Fourth Furcilia*

5 terminal spines on telson

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
196	3. iv. 27	50-0	1	1	8.16	8.16
197	3. iv. 27	100-50	6	6	8.58-9.46	9.12
198	3. iv. 27	50-0	5	4	8.38-8.75	8.55
199	3. iv. 27	50-0	1	1	8.58	8.58
		500-250	2	2	8.54-9.17	8.86
203	5. iv. 27	50-0	5	3	8.33-8.88	8.65
204	6. iv. 27	500-250	3	1	8.75	8.75
361	25. ii. 30	100-50	1	1	9.75	9.75
372	18. iii. 30	50-0	9	9	7.04-9.38	8.04
		100-50	2	2	7.00-7.38	7.19
373	19. iii. 30	50-0	6	6	7.08-9.29	7.92
374	20. iii. 30	50-0	21	21	7.13-9.92	7.74
		100-50	3	3	7.38-9.17	8.02
375	21. iii. 30	50-0	2	1	7.71	7.71
		500-250	19	19	7.00-9.25	7.96
861	27. iv. 32	109-0	19	19	7.75-9.33	8.74
		270-138	3	3	7.75-9.29	8.50
862	28. iv. 32	102-0	38	38	6.67-8.08	7.41
		220-98	2	2	7.50-8.13	7.82
887	27. v. 32	120-0	1	1	7.50	7.50
		86-0	8	8	7.67-8.83	8.19
		0-5	2	2	7.67-9.04	8.36
		235-115	1	1	8.33	8.33
888	28. v. 32	98-0	1	1	8.42	8.42
912	24. vi. 32	2-0	16	2	7.63-8.71	8.17
WS 427	28. iv. 29	100-50	2	2	7.79-7.88	7.84
WS 527	30. iii. 30	50-0	80	20	7.42-8.46	7.81
		100-50	2	2	6.83-8.33	7.08
WS 529	2. iv. 30	500-250	18	18	7.42-8.83	8.28
		750-500	10	10	7.08-8.58	7.93
			289	209	6.67-9.92	8.01

MANDIBLE. The lacinia mobilis is still present in the mandible. The palp is three-segmented, and in the specimen figured has two spines on the apex of the distal segment of the one, and only one on the other (Fig. 21 g). The variation in the number of spines in the distal segment is dealt with on p. 65.

FIRST MAXILLA. The palp of the 1st maxilla is unsegmented with seven bristles from the apex along the inner margin. There are two less conspicuous bristles on the outer side of the palp. The masticatory lobes are very similar to those found in the previous stage but with ten marginal bristles on the outer lobe. The pseudexopod rudiment is visible but not conspicuous in the region of the larval exognath (Fig. 21 h).

SECOND MAXILLA. The terminal palp of the 2nd maxilla (Fig. 21 j) has four bristles extending from the tip along the inner margin. On the outer side of the maxilla, where the palp is articulated, there is a little rounded process bearing two setae: this is the exopod. The segmentation of this appendage into three basal segments (*vide* Hansen's *Studies on Arthropoda*, II, 1925, pl. xii) is not clear.

FIRST THORACIC LIMB. The form of the 1st thoracic appendage (Fig. 22 *a*) is not much altered, the endopod is five-segmented and heavily setose, and the exopod, as before, primitive in shape and bearing four bristles distally. The joint at the base of the endopod is not clear. The length of the limb is about three-quarters that of the succeeding thoracic appendage.

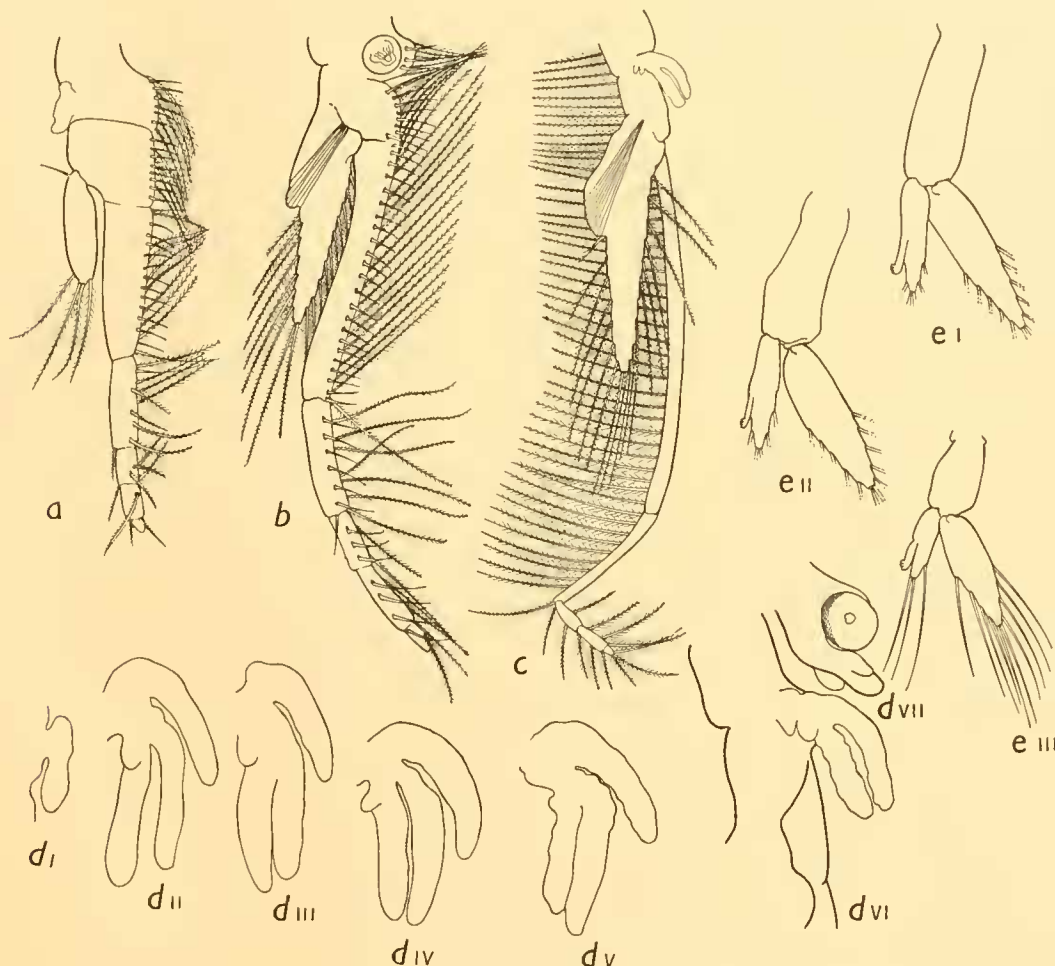


Fig. 22. Fourth Furcilia (continued).

a, thoracic limb I ($\times 35$); *d*, gills I–VII, the base of Th. VI and vestigial Th. VII in front of luminous organ ($\times 83$);
b, thoracic limb II ($\times 35$);
c, thoracic limb VI, lateral aspect ($\times 35$); *e* i, *e* ii, *e* iii, pleopods I, II and III ($\times 35$).

THORACIC LIMBS II–VIII. Thoracic limbs II–VIII are not greatly changed (Fig. 22 *b*, *c*). The exopods bear the following numbers of setae:

Th. II	inner margin	11,	outer margin	7
III	„	13	„	8
IV	„	13	„	8
V	„	13	„	8
VI	„	11	„	7

Situated on the inner side of the 7th gill and anterior to the luminous organ is a small digitate process not apparently branchial in function which is the vestige of the

7th thoracic appendage. Occasionally larvae belonging to this stage are found in which the process has a little spine at its tip. Th. IV is drawn in lateral aspect to show the typical flexion in the thoracic limbs.

One large larva included in this stage had traces of the eighth limb just distinguishable.

GILLS (Fig. 22 *d*). The gill on Th. I is single lobed and small, although more noticeable than in the preceding stage. Gills II–V are trilobed as in the preceding stage, but with two of the three lobes in each gill more or less equal to each other and the third rather short. The formation of a fourth lobe can be seen at the base of the innermost lobe, and in gill II still another incipient lobe at the base of the existing middle lobe. Gill VI is still bilobed but much larger than previously and has two small rounded processes basally. Gill VII is bilobed.

PLEOPODS. The pleopods (Fig. 22 *e*) are unaltered in general structure but have increased the number of marginal setae, there being now ten to twelve instead of eight to ten on the exopods.

LUMINOUS ORGANS. All the luminous organs are present.

Table XXXIV shows the incidence of larvae with four terminal spines on the telson. The infrequency of occurrence of this form is comparable to that already noted (p. 88) in larvae having six terminal spines, and the remarks made concerning the latter form of larva are equally applicable to that having four terminal spines.

Table XXXIV. *Occurrence of Furcilia larvae with four terminal spines on the telson*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
373	19. iii. 30	50-0	1	1	8.08	8.08
374	20. iii. 30	50-0	2	2	7.96-8.58	8.27
375	21. iii. 30	500-250	1	1	9.08	9.08
WS 427	28. iv. 29	50-0	1	1	9.00	9.00
			5	5	7.96-9.08	8.54

FIFTH FURCILIA

The frequency of occurrence of larvae of this form and their average lengths are stated in Table XXXV. The average length of all the larvae is 9.52 mm., and the range is between 8.25 and 11.50 mm.

The carapace (Fig. 23 *a*) has the rostrum less rounded and more angular in outline, and there is generally a distinct short broad spine at the apex. The lateral denticle on the carapace is more pronounced than in the previous stage.

The telson length is more than five times the breadth at the insertion of the smallest postero-lateral spine (Fig. 23 *c*). The posterior margin of the telson carries three spines on a border which is much narrower and more rounded than in the previous stage. In

dorso-ventral aspect the telson as a whole tapers from in front tailwards, except in the region of the insertion of the postero-lateral spines where there is a slight widening. The innermost postero-lateral spines are widened over a greater portion of the length than previously but tapered distally to a point. A few small bristles are found on the inner margin near the tip, but the dorsally projecting spinule has disappeared. The uropods are more setose than in the previous stage.

Table XXXV. *Occurrence of Fifth Furcilia*

3 terminal spines on telson

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
372	18. iii. 30	50-0	14	14	8.75-10.42	9.72
		250-100	1	1	8.88	8.88
373	19. iii. 30	50-0	27	27	8.63-11.04	9.49
374	20. iii. 30	50-0	16	16	8.67-10.08	9.31
375	20. iii. 30	500-250	22	22	8.46-9.83	9.31
		50-0	2	—	—	—
393	20. iii. 30	150-75	1	1	9.54	9.54
861	27. iv. 32	109-0	2	2	9.58	9.58
		270-138	1	1	10.83	10.83
862	28. iv. 32	102-0	12	12	8.25-9.58	8.92
		220-98	2	2	8.67-9.17	8.92
887	27. v. 32	120-0	1	1	8.50	8.50
		86-0	1	1	9.04	9.04
912	24. vi. 32	0-2	376	47	9.00-11.50	9.84
WS 527	28. iv. 29	50-0	1	1	9.17	9.17
WS 529	2. iv. 30	500-250	8	8	9.17-10.13	9.66
		750-500	1	1	9.04	9.04
			488	157	8.25-11.50	9.52

ANTENNULE. The flagella are greatly elongated, being nearly twice as long as the two distal peduncular segments. The dorsal lobes on the distal margin (dorsally) of the first and second basal segments are more pronounced than formerly (Fig. 23 *b, d*). The lateral spine on the first segment is reduced in size; this segment bears a number of bristles dorsally and on the outer margin.

ANTENNA. The differentiation of the rami of the antenna into scale and flagellum is complete (Fig. 23 *e*). The outer ramus forms a roughly oblong lamella with bristles along the inner and distal margins. The inner ramus consists of two peduncular segments and one or more flagellar segments according to the size of the larva, as shown on p. 64. The peduncle is articulated with the second segment of the protopodite in such a way that it appears at first sight as if the inner ramus had three peduncular segments. The insertion of the scale low down on the side of the second protopodal segment emphasizes this appearance. The proximal segment of the protopodite has a spine projecting forwards from the outer corner.

MANDIBLE. The lacinia mobilis is still present but very small and degenerate. The

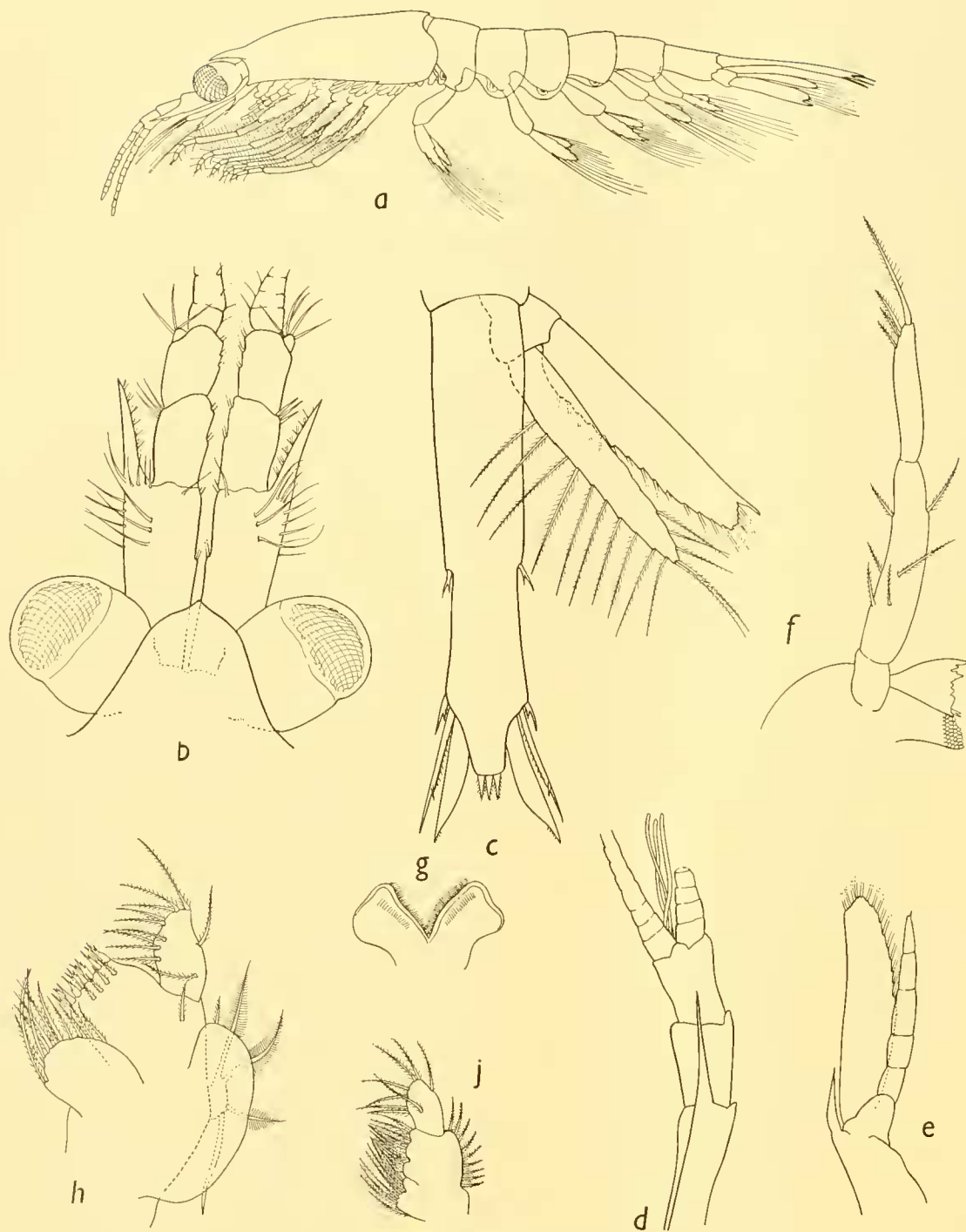


Fig. 23. Fifth Furcilia.

a, lateral aspect ($\times 12$);
b, antennules and rostrum ($\times 35$);
c, uropod and telson ($\times 35$);
d, antennule, lateral aspect ($\times 35$);
e, antenna ($\times 35$);

f, mandible ($\times 60$);
g, labrum ($\times 35$);
h, first maxilla ($\times 83$);
j, second maxilla ($\times 35$).

distal segment of the palp (Fig. 23 *f*) is longer and narrower than in the previous stage; the number of spines borne on it varies as shown on p. 67. The labrum is shown in Fig. 23 *g*.

FIRST MAXILLA. The palp and masticatory lobes of the 1st maxilla (Fig. 23 *h*) have more bristles than in the previous stage. The pseudexopod is now a conspicuous lamellar structure completely covering the larval exopod, extending nearly to the insertion of the palp and bearing a small bristle on its margin. The larval exopod is visible through the pseudexopod.

SECOND MAXILLA. The palp is now broader in proportion to its length and has more bristles than in the previous stage (Fig. 23 *j*). The exopod is more conspicuous and furnished with about nine setose bristles. The two distal lobes on the inner margin of this appendage have partially coalesced so that only four distinct lobes are now apparent.

FIRST THORACIC LIMB. The 1st thoracic appendage (Fig. 24 *a i*) is still shorter than Th. II. The exopod has a greater number of spines than formerly but has not yet assumed the shape typical of the other exopods.

THORACIC LIMBS II–VIII. The setae on Th. II–VI are more abundant (Fig. 24 *a ii, a iv*). The vestige of Th. VII (Fig. 24 *b vii*) bears a small spine and that of Th. VIII is a small inconspicuous lobe set internally to the gill. In one very large three-spined larva Th. VII was a conical process with a rounded tip bearing two small bristles and Th. VIII a similar but smaller structure with one bristle.

GILLS. The gill on Th. I is rather fusiform in shape and attached, not at its end, but at about one-third of the distance along one side (Fig. 24 *b i*). The gills of Th. II and III are four-lobed, of Th. IV and V five-lobed, of Th. VI four-lobed, of Th. VII three-lobed and of Th. VIII two lobed (Fig. 24 *b ii–viii*). In the last the two lobes are equal in length and much larger than in the previous stage. In the very large three-spined larva mentioned above the gill of Th. VII was four-lobed and that of Th. VIII three-lobed.

PLEOPODS. There is nothing to distinguish the pleopods (Fig. 24 *c i, c ii, c v*) from those in the previous stage except the number of setae which has increased so that there are now typically fourteen to sixteen on the exopods.

Table XXXVI records the occurrence of larvae with two terminal spines on the telson. This is the last of the aberrant telson forms. In its infrequency it is consistent with those which preceded it mentioned above on pp. 88 and 92.

Table XXXVI. *Occurrence of Furcilia larvae with two terminal spines on telson*

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
372	18. iii. 30	50–0	1	1	10.50	10.50
862	28. iv. 32	102–0	1	1	9.00	9.00
			2	2	9.00–10.50	9.75

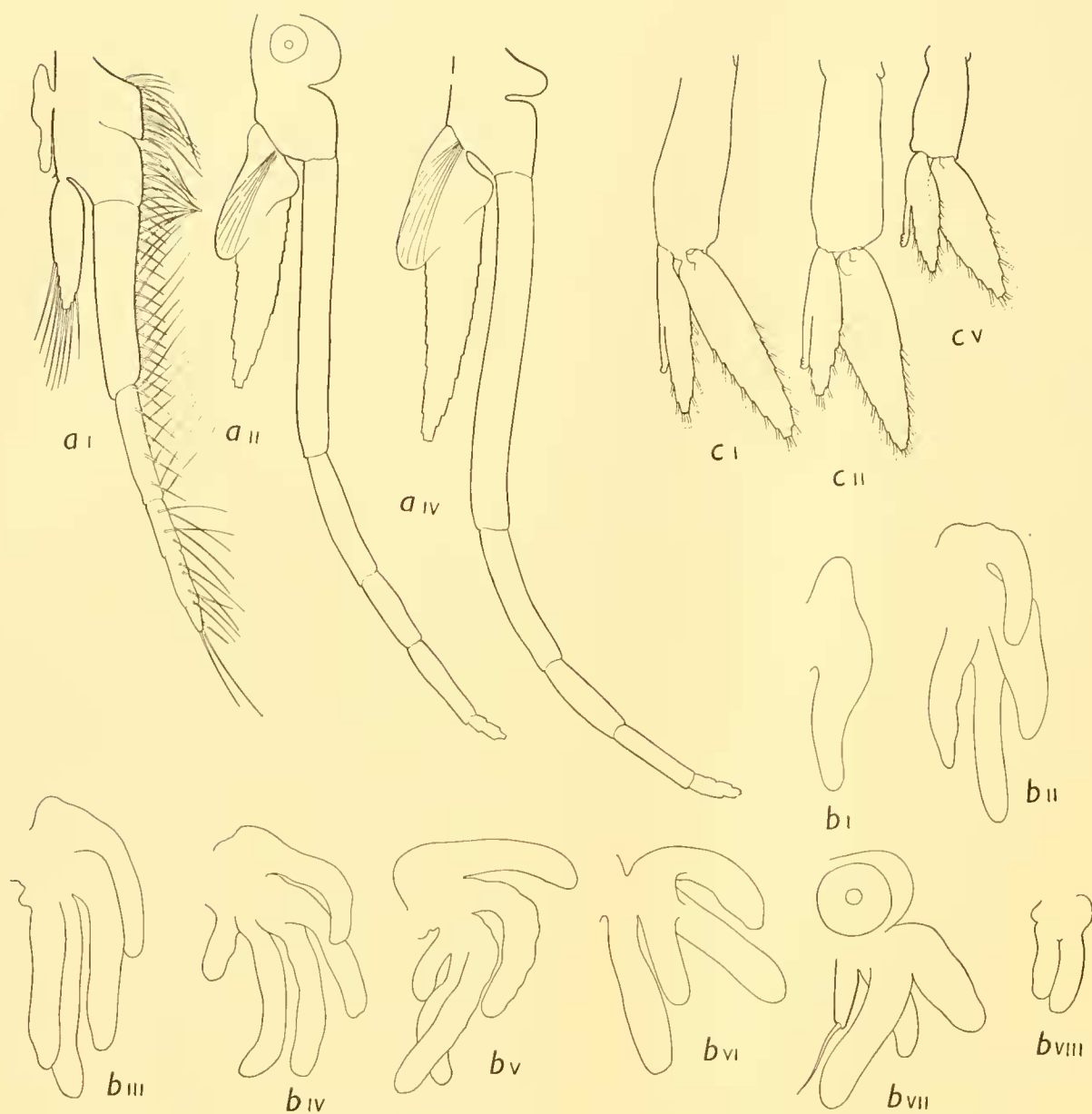


Fig. 24. Fifth Furcilia (continued).

a i, a ii, a iv, thoracic limbs I, II and IV ($\times 32$);

c i, c ii, c v, pleopods I, II and V ($\times 35$).

b i-b viii, gills ($\times 83$), Th. VII shown with gill.

SIXTH FURCILIA

The frequency of occurrence and average lengths of larvae belonging to this stage are stated in Table XXXVII.

The rostrum (Fig. 25 *a, c*) is much more acutely pointed than in the previous stage. The lateral denticle is conspicuous, and the emargination of the posterior border of the carapace is as shown in Fig. 25 *a*.

The telson length is more than six times the width at the insertion of the smallest

postero-lateral spines (Fig. 25 *b*). There is only one spine posteriorly, and with this condition the posterior border is reduced so that the lateral borders approximate to each other and are in alignment with the lateral borders of the median spine. Three postero-

Table XXXVII. *Occurrence of Sixth Furcilia*

One terminal, three postero-lateral spines on telson

Station	Date	Depth m.	No. of larvae	No. measured	Length range mm.	Average length mm.
373	19. iii. 30	50-0	1	1	10.00	10.00
374	20. iii. 30	50-0	1	1	9.42	9.42
375	21. iii. 30	500-250	3	3	10.42-11.63	11.21
393 ^A	7. v. 30	150-75	1	1	9.54	9.54
471	31. x. 30	50-0	33	33	9.50-15.00	11.76
477	13. xi. 30	50-0	2	2	11.00-12.50	11.75
483	14. xi. 30	50-0	17	17	10.50-14.50	11.96
		100-50	8	8	12.50-15.50	13.56
484	16. xi. 30	50-0	13	13	11.00-14.50	12.48
		100-50	1	1	13.25	13.25
862	28. iv. 32	102-0	4	4	9.25-10.33	9.79
912	24. vi. 32	2-0	1088	136	10.00-13.50	10.85
954	9. ix. 32	0-5	23	23	11.00-13.00	11.57
955	9. ix. 32	0-5	7	7	10.00-12.00	10.96
956	9. ix. 32	97-0	1	1	10.25	10.25
		280-100	1	1	11.25	11.25
957	10. ix. 32	0-2	2	2	10.50-13.00	11.50
959	11. ix. 32	0-5	3	3	11.50-12.50	11.75
		91-0	1	1	12.75	12.75
WS 255	22-23. viii. 28	50-0	1	1	8.96	8.96
WS 263	28. viii. 28	500-250	2	2	8.00-11.00	9.50
WS 266	29. viii. 28	750-500	1	1	9.20	9.20
		1000-750	1	1	11.50	11.50
WS 268	29. viii. 28	250-100	1	1	9.20	9.20
WS 270	30. viii. 28	50-0	1	1	10.80	12.30
WS 274	4. ix. 28	250-100	1	1	9.87	10.80
WS 275	4. ix. 28	100-0	2	2	9.37-10.37	9.87
WS 284	18. ix. 28	50-0	2	1	12.75	12.75
WS 286	18. ix. 28	50-0	5	5	10.00-13.00	11.15
WS 287	19. ix. 28	50-0	1	1	10.75	10.75
WS 304	6. x. 28	50-0	1	1	11.75	11.75
WS 307	7. x. 28	50-0	2	2	13.00-14.00	13.25
WS 310	8. x. 28	50-0	2	1	16.75	16.75
WS 527	30. iii. 30	50-0	8	2	10.08-10.29	10.19
WS 529	2. iv. 30	500-250	2	2	10.42-11.96	11.19
WS 573	25. iii. 31	50-0	1	1	9.80	9.80
			1244	284	8.00-15.50	11.34

lateral spines are still present, the innermost flattened and wide throughout most of its length; the middle spine is rather reduced but bears the normal spinules on the inner and dorsal surfaces. The telson is roughly double the length of the sixth abdominal segment.

ANTENNULE. The flagella are longer in proportion to the body length than those in the previous stage, but in preserved material they are usually broken off. Sensory filaments are present at the base of the outer flagellum. The lobes on the anterior margins of the basal segments are more pronounced (Fig. 25 *c*).

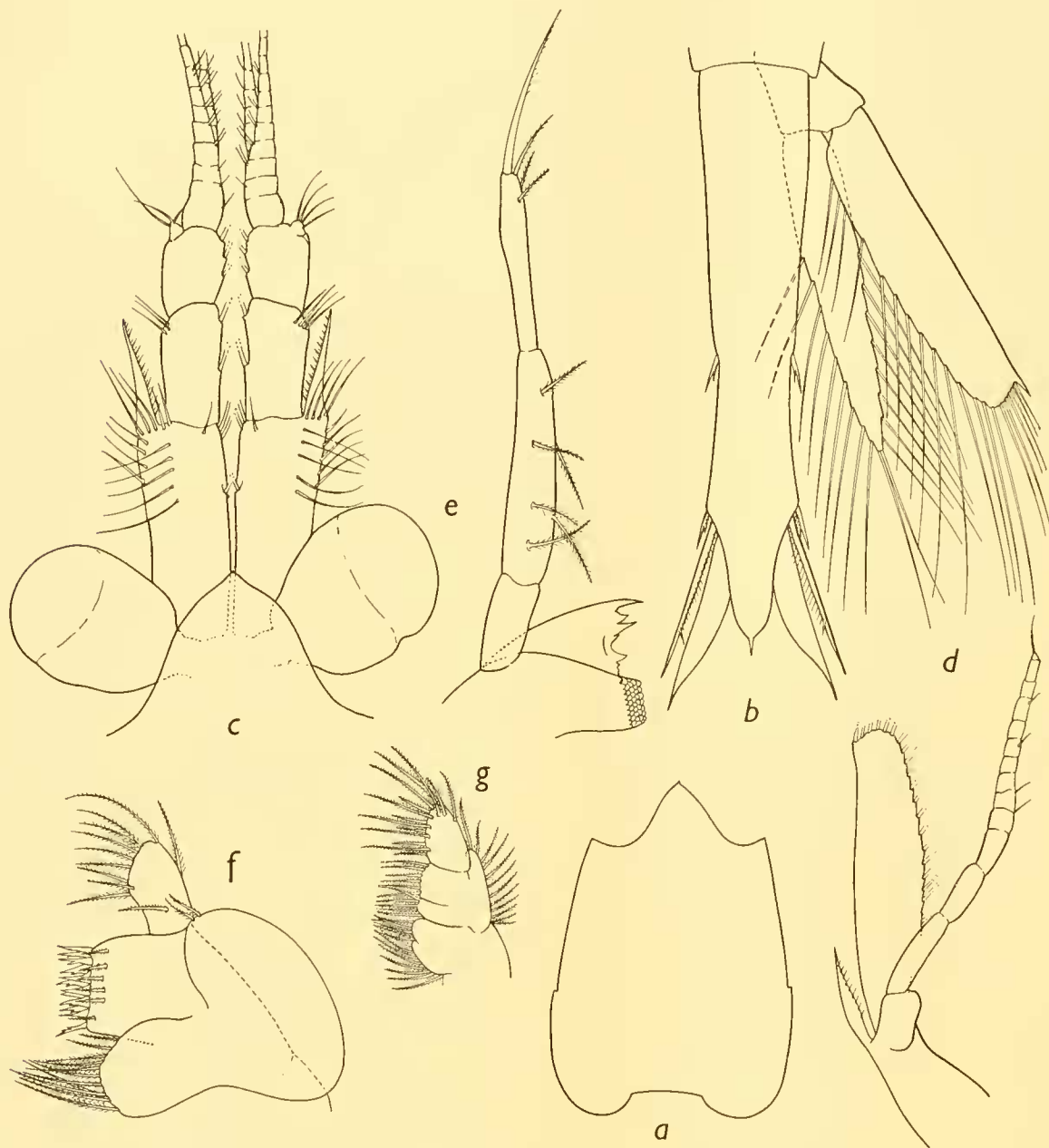


Fig. 25. Sixth Furcilia.

a, carapace ($\times 13$);

b, uropod and telson ($\times 35$);

c, antennules and rostrum ($\times 35$);

d, antenna ($\times 35$);

e, mandible ($\times 60$);

f, first maxilla ($\times 83$);

g, second maxilla ($\times 35$).

ANTENNA. The scale is more heavily furnished with setae on its inner margin than in the previous stage; the flagellum is multi-articulate and much longer than the scale (Fig. 25 *d*). The spine on the basal segment is furnished with little bristles on its inner margin. The second basal segment is indistinctly articulated with the first and appears like an additional peduncular segment of the inner ramus.

MANDIBLE. The lacinia mobilis has disappeared on the specimen figured, and in all the other larvae examined belonging to this stage no lacinia mobilis was seen. The palp (Fig. 25 *e*) is more elongate than in the previous stage and the number of spines on the distal segment is increased: the variations in spine number are dealt with on p. 67.

FIRST MAXILLA. The palp is slightly shorter and broader than in the previous stage, but the masticatory lobes are similar. The larval exopod has disappeared and the pseudexopod extends to the joint of the palp bearing on its margin two or three little bristles (Fig. 25 *f*).

SECOND MAXILLA. This appendage (Fig. 25 *g*) consists now of three portions: distally the palp, which is broader in proportion to its length than in the previous stage; a middle portion with two lobes internally and the digitate process of the exopod externally; and proximally a basal portion bearing two lobes internally.

FIRST THORACIC LIMB. The exopod of Th. I (Fig. 26 *a i*) has lost the larval form and has now a distinct "shoulder" on the outer margin. The number of bristles on the exopod has increased so that there are five on the outer margin and three on the inner.

THORACIC APPENDAGES II–VIII. The exopods of Th. II–VI show more clearly the articulation of the basal with the terminal part, and the natatory setae are increased in number. Only Th. VI is figured (Fig. 26 *a vi*). The endopod of Th. II is shorter than that of Th. III and there is a decrease in size from Th. III backwards. Th. VII (Fig. 26 *b vii*) is an inconspicuous process bearing two setae terminally and Th. VIII (Fig. 26 *b viii*) is a still smaller vestige which may or may not have a seta. Th. VII and VIII are figured along with the gills belonging to these appendages.

GILLS. The gill or epipodite of Th. I (Fig. 26 *b i*) is similar to that seen in the previous stage. The gills of the remaining thoracic limbs (Fig. 26 *b ii–viii*) are more developed than previously, those of Th. II and III are five-lobed, Th. IV is also five-lobed with indications of a further lobe developing. The gills of Th. V and VI are similar in development to those of the preceding stage. The gill of Th. VII has four well-developed lobes and two more short lobes developed in proportion to the size of the larva: two different conditions of this gill have been figured. The gill of Th. VIII has three large lobes and two small ones near the peduncle.

PLEOPODS. There is an increase in the number of marginal bristles (Fig. 26 *c i, ii, v*) and the appendix interna (Fig. 26 *d*) has four or five hooks.

ADOLESCENT FORMS

Rustad (1930, p. 68) gives reasons for the abandonment of the term "post-larval" to describe the stages which succeed those formerly classed as Cyrtopia. He states that the latter stages merge gradually into the adult and points out, what Dr Bargmann has also

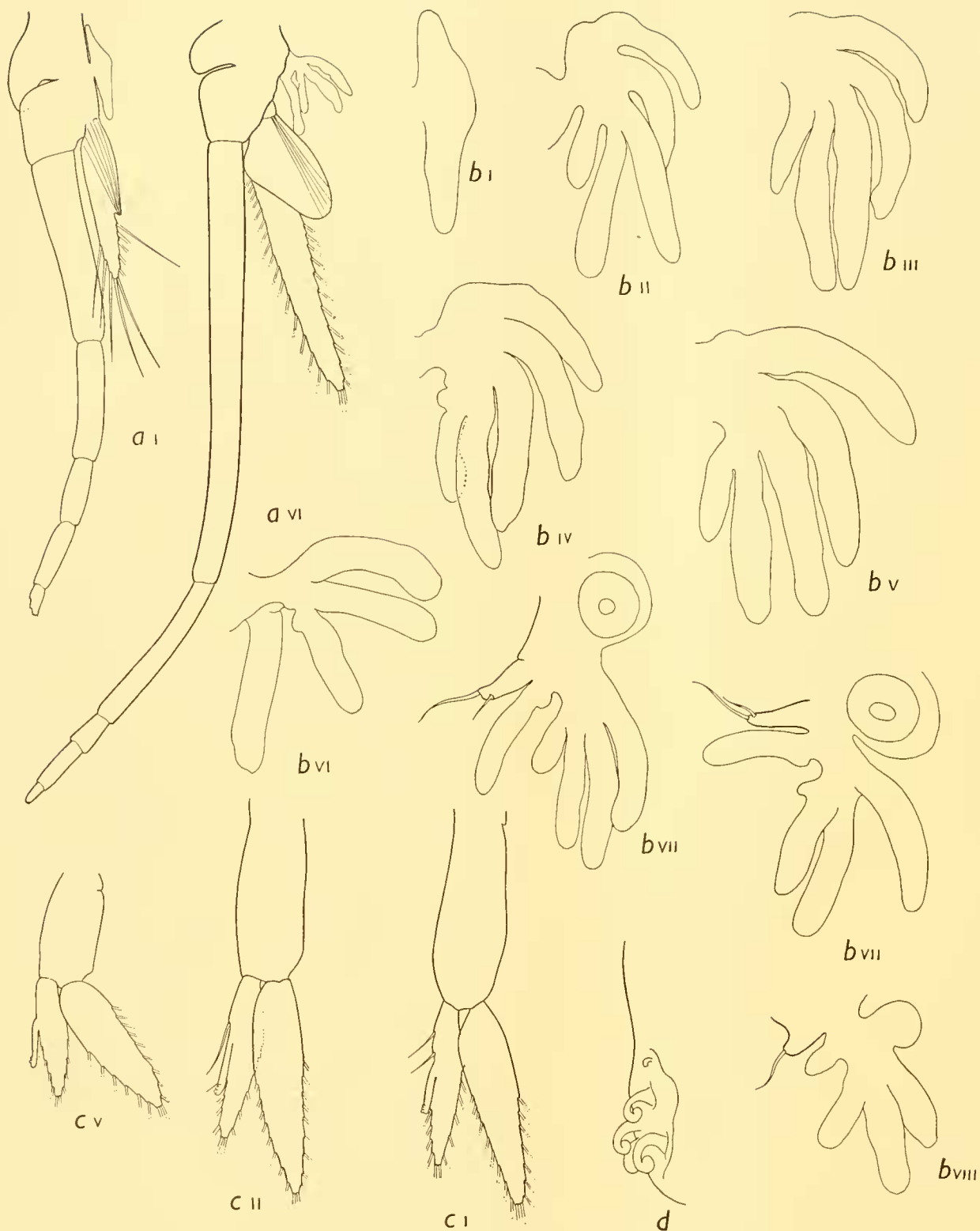


Fig. 26. Sixth Furcilia (continued).

a i, thoracic limb I, bristles on endopod omitted ($\times 35$);

a vi, thoracic limb VI, bristles on endopod omitted ($\times 35$);

b i–*b viii*, gills I–VIII, two forms of gill VII showing Th. VII, *b viii* showing Th. VIII ($\times 83$);

c i, *c ii*, *c v*, pleopods I, II and V ($\times 35$);

d, hooks on appendix interna ($\times 165$).

observed in *Euphausia superba*, that sexual maturity may be reached before the adult form is attained. It is proposed therefore in the present paper to use the term "adolescent" to describe that portion of development between the 6th Furcilia stage and the part of the life history where changes take place associated with sexual maturity. The scope of the paper, so far as adolescents are concerned, is limited to the younger individuals in this phase and does not include reference to those that from their size require special examination to decide whether they are adolescent or adult.

By the time the euphausiid reaches the 6th Furcilia stage the major developmental changes have been effected and in appearance it is characteristically a euphausian. Such alterations as take place subsequently chiefly involve the elaboration of existing structures, for instance, increase in the number of setae on the antennal scale, in the number of segments in the antennular flagellum, in the number of lobes on the branchiae, and so on. These changes are gradual and show great individual variation. Attempts which were made to arrange the adolescents in groups or stages dependent on the number of setae on the antennal scale did not yield any satisfactory results, and it was made obvious by inspection of the animals that in other appendages as well no hard and fast pattern of development exists.

It should be emphasized again that this generalized development is not an exclusive feature of the adolescents, but that it is incipient, in some characters at any rate, in early Furcilia stages and becomes more and more evident as development goes on. Thus although Furcilia 6 is recognized in the main by having one terminal and three postero-lateral spines on the telson, as opposed to two postero-lateral spines in the adolescent, yet the distinction between the two stages is diffuse and ill-defined.

In Appendix I the length frequencies of late Furcilia and early adolescents taken in the 1-m. nets have been set out. The time of year when the larvae were obtained, the total number and the number examined, the average length for each phase of development, the percentage of the total in each phase and the general average have been stated.

The first point to be noted from this analysis is that Furcilia 5, representing larvae about 8 mm. in length, although occurring in August and September is in such very small numbers that it may fairly be concluded that the vast majority of the larvae reach the Furcilia 6 stage before the end of the southern winter.

Inspection of the table shows that the total number of *E. superba* at different stations varies very greatly, and that the small numbers at some of the stations tend to give anomalous results. It is possible, however, to get an approximate indication of the relative abundance of the two phases of krill principally represented, namely Furcilia 6 and adolescent.

In Table XXXVIII the average percentage occurrence of Furcilia 6 is stated. The percentages from which these averages are derived are of catches where the number of euphausians examined was considered sufficiently high to give a trustworthy idea of the proportions in which Furcilia 6 and adolescents were present.¹

¹ The arbitrary number of 48 was selected.

Table XXXVIII. *Average percentage occurrence of the sixth Furcilia*

	1928-29	1929-30	1930-31
August	75	—	—
September	49	—	—
October	35	—	19
November	—	10	16
December	—	0	0
January	—	0	0

It is seen that there is a decrease from August to December from a stock three-quarters of which are Furcilia 6 to one in which this stage is not represented.

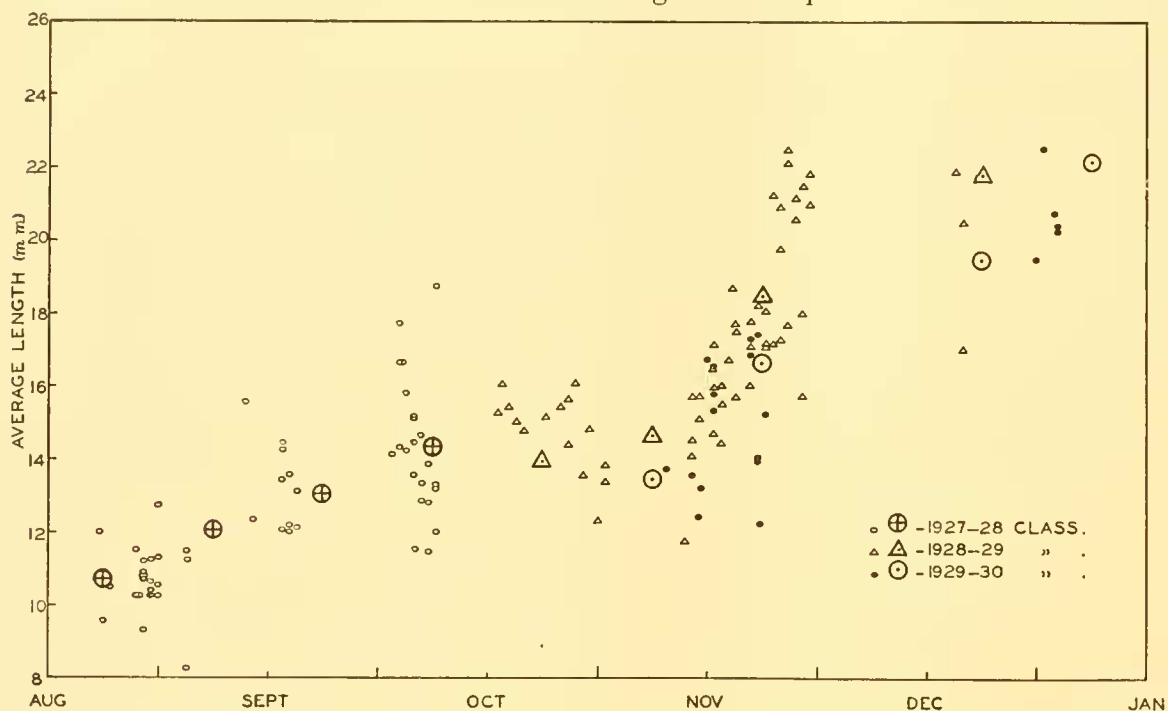


Fig. 27. Average length of second season krill. The smaller signs express average lengths of individual samples, the larger ones the half-monthly average lengths of all the young euphausians taken.

An impression of the length range of Furcilia 6 is easily obtained by reference to the appendix. The way in which the upper limit of length overlaps the lower limit of the adolescent size range emphasizes the indefinite nature of the division between the two phases of developmental history. The length range of Furcilia 6 covers 9 mm., extending from 8 to 17 mm. with a mean length of about 12 mm. But it is possible to get adolescents 10.5 mm. long, so that there is an overlap in the two length ranges of 6.5 mm.

In Fig. 27 the average lengths of the krill from the samples referred to above are depicted. The smaller signs express average lengths of individual samples and the larger ones the half-monthly average lengths of all the young euphausians taken. The three seasons' catches have been given the designation of classes, that is to say the 1927-8 class represents larvae which originated in that season. They would be adolescents in the 1928-9 season and adult in the succeeding season.

The figure shows the great range of average size which can be encountered at any one period. For instance, in the month of November the range in average length (not individual length) is between 11.8 and 22.5 mm.—this from samples of the same year class. This range is almost equal to the increase in average length for the whole period under discussion, namely the second half of August to the first half of January. Although there is this great range in size for any one period, there is a definite and fairly regular increase in the half-monthly average size. In the second half of August the average length of the larvae is 10.70 mm.; in the first half of January it is 22.18 mm. These figures involve results from two different year classes, but inspection of the figure shows that in those instances where observations were made over the same period in different seasons, the half-monthly average length shows such a small variation that it seems justifiable to assume that the rate of growth is approximately the same in different years.

ANOMALOUS LENGTH FREQUENCIES IN ADOLESCENT FORMS

In his reports to the Discovery Committee on the results of the circumpolar cruise, John drew attention to the length grouping of the young krill in the catches obtained. His remarks have been incorporated in the account of the circumpolar cruise on p. 137 below. The larvae from St. 954 fell into two well-defined groups having their maxima at 13 and 18 mm. respectively: this was in September. Later, in October–November, John depicts (Fig. 61) the difference in constitution between krill taken in the Bellingshausen Sea, in the ice-free water near South Georgia and in the Weddell Sea. The two sets of data involve two different problems: (a) the occurrence of two distinct length groups simultaneously in the one locality, and (b) the occurrence, in different localities at approximately similar times, of young *E. superba* differing widely in length frequency.

There is no obvious explanation for the occurrence of two different length groups in the same locality simultaneously, and the statements made here must be regarded as conjectural.

John's report of this occurrence led to the reconsideration of certain records from 1-m. net catches where groups of *E. superba* had been measured and discarded from the material used in this paper. They were regarded as being outside the range of larval and adolescent lengths here dealt with and were given the provisional designation of "small adults". Thus at St. WS 279, 13. ix. 28, including the "small adults", a bimodal curve was obtained having maxima at 12.37 and 27.4 mm. respectively. There were 163 larvae in the first group and forty-eight in the second, the two groups being separated by 8 mm., from 16 to 24 mm., within which no larvae were found. Again at St. WS 288, 19. ix. 28, the euphausians were arranged in two groups, the one with average length of 13.13 mm. and the other with average length 25.18 mm. There were over 20,000 of the smaller larvae and only thirty-seven of the "small adults"; the two groups were separated by a space of 5.5 mm.

If the three sets of results detailed above from Sts. 954, WS 279 and WS 288 are

considered together the peculiar nature of the larger of the two groups is evident. The average growth curve on p. 108 below shows that the average length of the larger group is in each instance much greater than that represented in the graph. Thus in September the normal average is about 12 mm. as opposed to 18 mm. in John's larger group. In October the normal average is about 13 mm. as opposed to 27 and 25 mm. in the "small adults" from Sts. WS 279 and WS 288. Ruud's mean length diagram (1932, p. 41, fig. 8) shows that in October the mean length of adult krill is about 50 mm., so that our "small adults" fall somewhere between the normal adolescent average length and fully adult average length.

The origin of these anomalous forms is not clear, and what the factors are that influence their difference in size is open to speculation. It may be that they are derived from batches of eggs laid very early in the summer season that have pushed ahead with development, obtaining the full benefit of the summer season, whereas the majority of the larvae encountered only obtain benefit from the latter part of the summer, having been derived from eggs laid well on in that season. It may be, as John suggests, that specially favourable environmental conditions, for instance a rich diatom flora, may have been the lot of some of the larvae for a greater period than the remainder. Whatever be the true explanation, the fact that forms occur having this peculiarity of length leads to enquiry as to when they become sexually mature. If the growth rate in these euphausians is similar to that in normal circumstances there is every possibility that they reach a size at which they are sexually mature before the coming of the second winter. If this does occur the complications to be encountered in unravelling the constitution of the adult krill population are greatly increased.

The occurrence of young *E. superba* differing widely in length frequency in different localities at approximately similar times was described by John in a comparison of larvae from the Bellingshausen Sea, from the Weddell Sea ice-edge and from stations in open water west of South Georgia. The period covered was little more than a month and the contrasted results are referred to on p. 141 and shown in Fig. 61. He suggests that better conditions for growth, such as the more abundant diatom flora, may account for the larger size of some of the larvae as compared with the others.

Apart from one instance, mentioned below, no attempt has been made in this paper to correlate the occurrence of diatoms with the krill results. It is regretted that it has not been possible to fulfil the promise implied in Hart's Phytoplankton Report (1934, p. 11). The detailed investigation of this very important field of research will, it is felt, clear up many of the problems connected with the growth and distribution of krill.

The correlation is inserted as it has a bearing on John's suggestion concerning variation in richness of the food supply. In Fig. 28 is shown the average length of adolescent *E. superba* and the abundance of *Thalassiosira antarctica* at the stations indicated. The presence, but not the abundance, of *Chaetoceros socialis* is also represented in the figure; this small colonial form occurred in such great numbers that its abundance could not be estimated satisfactorily. The stations from which the data were taken were all made in

the South Georgia plankton survey of November 1930. An account of the phytoplanktonic conditions prevailing is given by Hart (*loc. cit.*, pp. 41 *et seq.*). Concerning *Chaetoceros socialis* he writes (p. 51): "*Chaetoceros socialis*... was taken at fourteen stations only, all of which were grouped towards the southern extremity of the island, some close inshore, and the others in the neighbourhood in which the pack-ice lingered longest during this spring, and all in the water which from the general nature of the phytoplankton as a whole, almost certainly originated in the western Weddell Sea." Concerning *Thalassiosira antarctica* he writes: "It also reached its greatest abundance in the western Weddell Sea surface water round the southern end of the island and was comparatively rare to the north and north-west. It was, however, very widely distri-

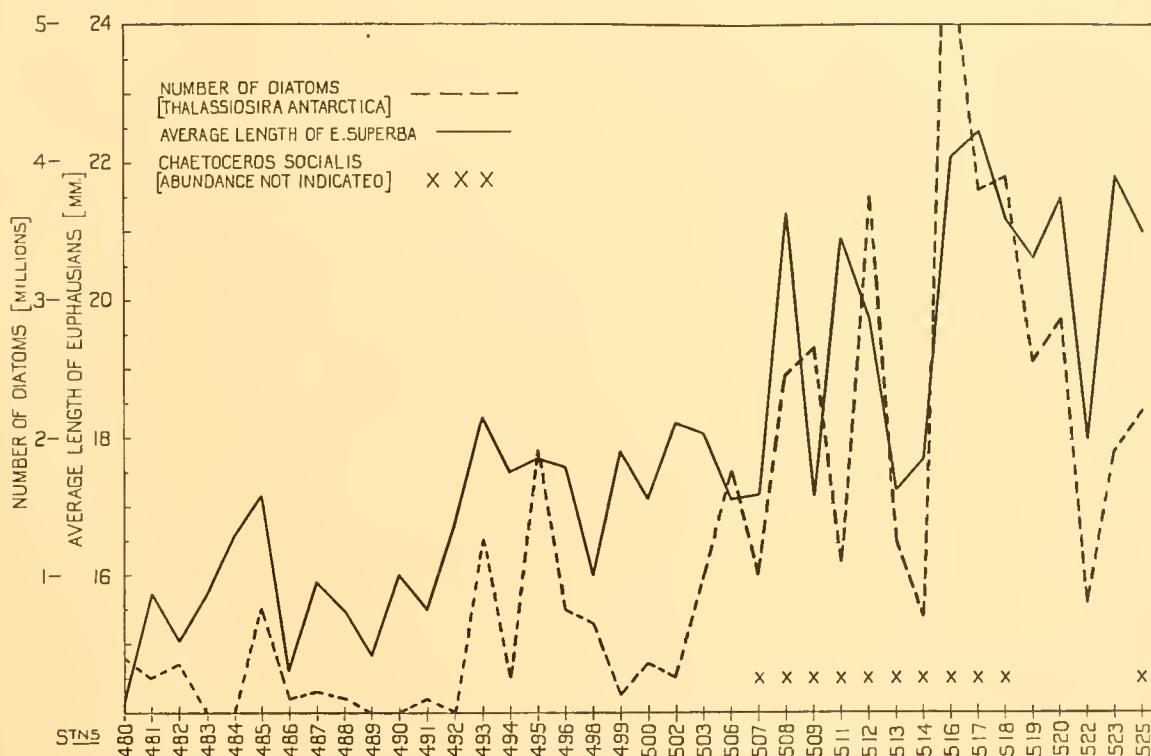


Fig. 28. Diagram showing the relationship between the average length of *Euphausia superba*, the abundance of *Thalassiosira antarctica* and the occurrence of *Chaetoceros socialis*.

buted, being taken at all but six stations on this survey. It occurred in the eastern Weddell Sea water in considerable numbers. The minute form growing in gelatinous colonies which defied estimation was, however, confined to the densely populated region to the south-west with the single exception of the anomalous St. 493 on the Larsen Line." In his summary too he states (p. 64): "The richest and most varied flora was found in the water, mainly of Weddell Sea origin, to the south and south-west of the island. Here the dominant forms were *Chaetoceros socialis*, *Thalassiosira antarctica* and *Chaetoceros neglectus*."

Fig. 28 shows that it was at the stations where *Chaetoceros socialis* and *Thalassiosira antarctica* were most abundant that the young krill reached its greatest average length.

On the left of the figure, where *Chaetoceros socialis* is absent and *Thalassiosira antarctica* less abundant, the average size of the krill is small, but on the right, representing stations at the southern end of South Georgia, the average length is greatly increased, and it is here that the two diatoms reach their maximum. It is open to question whether the increase in size of the krill is a direct result of the greater abundance of these particular diatoms, or whether the correlation rests on a community of environmental conditions, namely those to be found in the western Weddell Sea water affecting diatoms in abundance and the euphausian in length.

The results of Hart's examination of the stomach contents of adult and post-larval *Euphausia superba* suggest that the correlation between abundance of *Thalassiosira antarctica* and increased average length of the euphausians is a direct one: for he states that on the occasions when this examination was made, of two forms which occurred constantly, one was *Th. antarctica*.

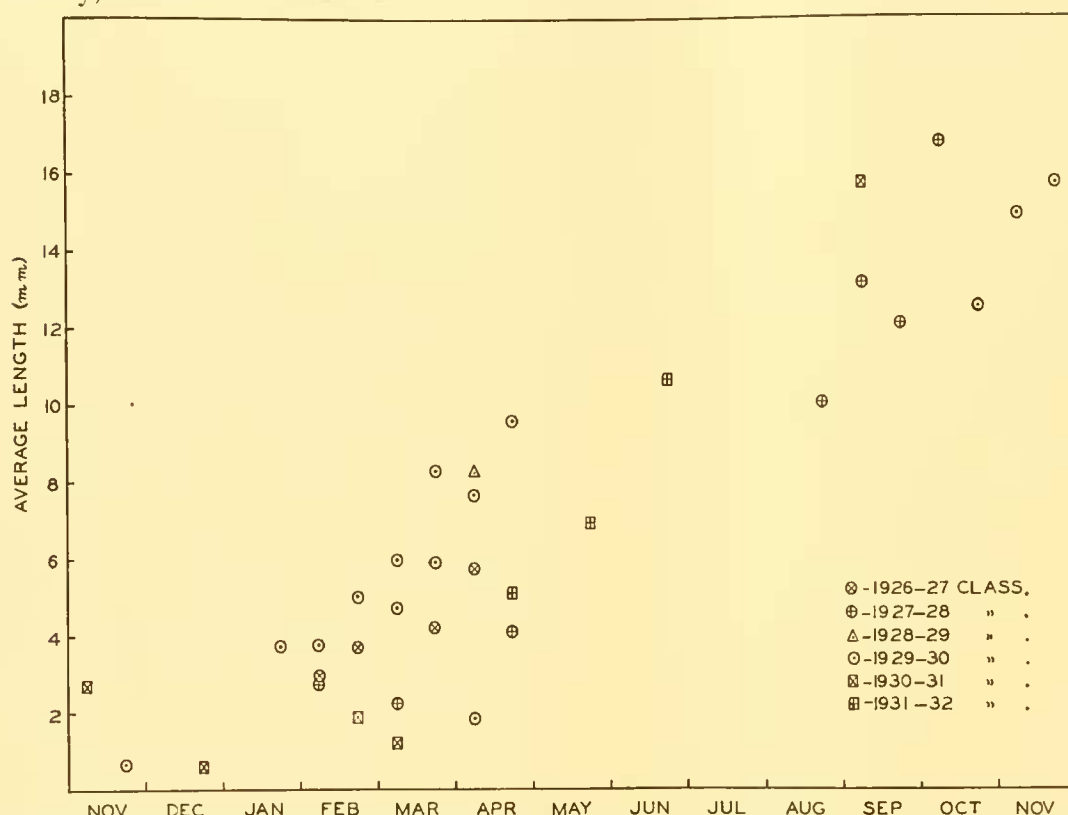


Fig. 29. Half-monthly average length of *Euphausia superba* larvae obtained from 70-cm. vertical nets and from the 1-m. nets fished during the circumpolar cruise.

AVERAGE LENGTH OF LARVAE

In Fig. 29 there is represented the half-monthly average lengths of the *Euphausia superba* larvae obtained from the 70-cm. vertical nets, except for the 1931-2 series which was taken in the 1-m. nets fished during the circumpolar cruise. The scattered distribution of the average lengths gives some indication of the variation which can take place. It is in part due, no doubt, to the different seasons involved and to local environmental

dissimilarities which must accelerate or retard the growth rate in accordance with favourable or unfavourable conditions.

Comparison of size with locality of occurrence gave no satisfactory result, nor is there any clear suggestion that larval development periodically commences sooner in one area than another. There is perhaps a hint that in the South Georgia region this may be so, but it is so ill-defined in the data as to be of little importance.

Notwithstanding the great variations in average length which exist at any one time, the figures as a whole show an upward trend from early in the summer season to the end of it, so that by June the larvae have attained an average length of 10.6 mm. The June figure is the only record for that period of the year, but it is from a reasonably large number of measurements and may be considered fairly representative. There is not another record until the second half of August when the length of a small number of larvae in a different season is 10.02 mm. The averages from August onwards are of small numbers of Furcilia 6 and adolescents and for these a better indication of what happens is obtained from the results of the 1-m. net samples set out above.

It may be concluded then that the larvae generally reach a length of about 10 mm. by the time the winter sets in and that this size has been achieved in a period of six months.

AVERAGE GROWTH RATE

Fig. 30 is constructed on the data shown in Figs. 27 and 29 above. It attempts to give some impression of average growth rate during the first year or so of larval life. From November to August the figures represented are the half-monthly average lengths of all the first season larvae taken during that period. From August to January the graph is a repetition of Fig. 27.

The interpretation of the curve of average growth is straightforward in this second portion, but the first part requires some comment. The figure for the first half of November is derived from a single individual. The figures for the second half of December and second half of January are from four and five measurements respectively. In the beginning of January and February numbers have increased to 368 and 112 respectively, and in the second half of February and first half of March they are 1966 and 6602. The next three half-months have roughly comparable figures in the thousands.

The average lengths during this period show no well ordered progression in size. In January and February these figures are very much greater than in the first half of March, where there is a large population with greatly reduced average length. In the second half of March the average length increases again by about 4 mm. The position of the first portion of the average length curve, as shown in the graph, is suggested by these figures. The large number of very small larvae in the first half of March counteracts the effect of the lesser numbers of greater length before and after that time and makes the upward tendency of the growth curve less steep.

It is possible that the conjectured earlier development of larvae in the South Georgia region, referred to in the previous section, is responsible for the differences between the January-February period and March. In the former of the two periods the average

lengths are derived, in two of the three half-months, from larvae taken near South Georgia and in the third half-month from the South Shetland-South Sandwich area. The low figure for the first half of March is caused by the great numbers of Metanauplius and 1st Calyptopis taken at stations just north of the South Shetlands in that half-month. But this indefinite division into a north and south area breaks down altogether in the second half of March and first half of April, where the contrasted results

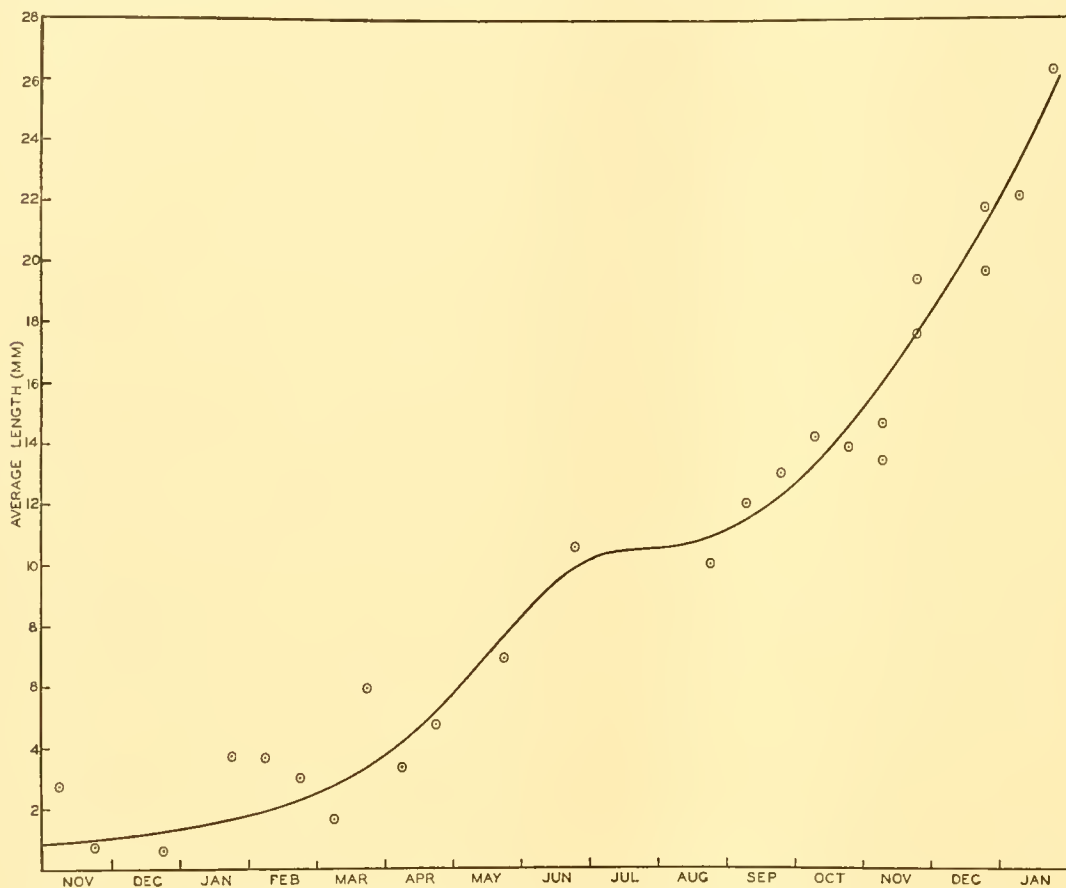


Fig. 30. Graph showing average growth rate of *Euphausia superba* during the first fifteen months of larval life.

of the two periods are both derived from larvae from the Bransfield Strait and South Sandwich Islands-Burdwood Bank Line.

The growth curve can be divided into four parts: a low, gently increasing portion from November to March, a steeper portion between March and June, a part having little or no upward tendency between June and August, and a steeply ascending portion from August onwards.

The first part of the curve coincides with the observed period of spawning. The average length of the larval krill population will be kept down by the constant addition of very small developmental forms; it is a period of production and growth. The second part extends from the end of the spawning period to the time when winter conditions become effective. During this period the average length is not affected by influx of very young

larvae to the stock—it is exclusively a period of growth. The third division of the graph coincides with the depth of the southern winter when conditions for growth will be unfavourable, and although the June average depends on one sample it may be taken that it represents, roughly at any rate, what actually happens at that time of year. With the coming of spring, environmental conditions become favourable again and growth and development go ahead. The larvae pass from Furcilia 6 to the adolescent phase, so that by the end of the year the former stage of development is no longer encountered in the samples.

This curve of average length corresponds fairly closely with the comparable portion of Ruud's Total Growth Curve (Ruud, 1932, p. 45, fig. 10), but in the present figure the first period referred to above is continued for at least a month longer than Ruud's figure indicates. The period of rapid growth prior to winter covers the period April–June, as compared with February–March depicted in Ruud's figure. This last difference affects the length of the winter period of reduced rate of growth. On the whole, however, the results are in fair agreement, and what differences there are probably originate from the widely separated sources from which the present material was obtained.

The distribution of records throughout the year with the exception of the month of July helps toward a better understanding of the development and growth of this euphausian than was hitherto possible, and although many of the results cannot be regarded as final and conclusive, they at any rate furnish a basis for future corroboration or contradiction.

DISTRIBUTION

EGGS

REGIONAL DISTRIBUTION

In the samples examined there are forty-eight records of eggs from twenty-eight different stations. Most of the catches are of small numbers of eggs, but at one station, St. 540, relatively enormous numbers were obtained, of which the maximum occurred in the 500–250-m. net.

In the Falkland sector, from which all the data relating to eggs have been obtained, they were found in great abundance near Graham Land and the South Shetlands or in the path of currents which have a component towards these places (Fig. 31). They were also found near the South Orkney Islands and South Georgia and above the Scotia Arc in the vicinity of the South Shetlands. They were also found close to the continental shelf west of Graham Land in the south of the Bellingshausen Sea.

The area of greatest abundance of eggs is near the northern end of Graham Land, particularly in the Bransfield Strait; at each group of stations made there between November and February eggs were found in greater or less abundance.

There are probably two main reasons why eggs occur in the regions described. Along the west coast of Graham Land and the Scotia Arc, as far as the South Sandwich Islands at all events, the temperature and salinity are roughly the same (*vide* Deacon, 1933, figs. 12, 13, 24), and these conditions are probably the optimum for eggs to be laid.

These same conditions are continued with small modifications towards the north near South Georgia and the Shag Rocks.

The second reason is probably to be found in the bathymetric conditions. West of Graham Land and in the neighbourhood of the South Shetlands, South Orkneys, South Sandwich, South Georgia and the Shag Rocks there are extensive areas of comparatively shallow water, and on the Scotia Arc joining these regions (*vide* Herdman, 1932, p. 214) the sounding is generally less than 2000 m. If, as will be suggested later, the eggs develop near or at the bottom in comparatively deep water, the depths in these regions are probably most suitable.

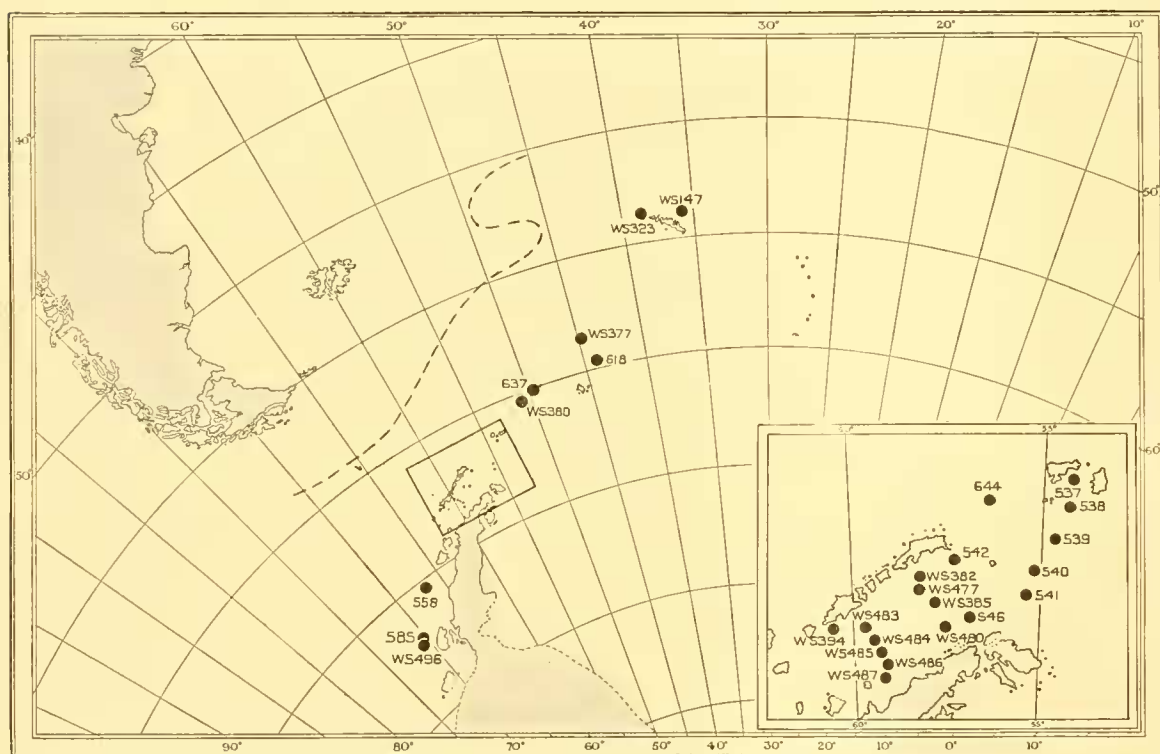


Fig. 31. Distribution of eggs of *Euphausia superba*.

The reason for the particular abundance in the Bransfield Strait area may be that temperature and salinity or the bathymetric conditions are particularly suitable. For, in the Bransfield Strait and separated from the surrounding seas by submarine ridges rising to within 250–600 m. of the surface, there are extensive basins with soundings from 500 to 2000 m. These basins may be particularly favourable for the production and development of eggs. One other striking feature of this region which may make it suitable is the homogeneous condition of the water column. Over the shallow ridges the water is almost completely mixed, and even in the deep basins there are only small changes of temperature and salinity with depth.

The eggs were found in nets fished through water of which the temperature varied from -1.80 to 2.02°C ., but the greater number of catches was in water of temperature

less than 0° C., and the greatest numbers of eggs were taken from water of this low temperature.

In salinity the conditions found at St. 540 seem to indicate some approximation to the optimum for the occurrence of eggs. At this station the salinity is between 34.36 and 34.62 parts per thousand, and at others, where the eggs are comparatively plentiful, the salinity corresponds more or less closely to these limits.

VERTICAL DISTRIBUTION

Eggs occurred in all six nets of the vertical series fished from the surface down to 1000 m., but the bulk of them were found below 250 m. At stations where more than one net yielded eggs, and where large numbers were found, the greater proportion was in the lower nets. The depths of the nets in which eggs were found is given in Table III. At all stations a series of closing nets was fished from the surface downwards, but above the shallowest net mentioned no eggs were obtained.

The percentage of the total number of eggs per 50 m. unit in each of the six hauls is as follows:

50- 0 m.	0.8 %
100- 50 m.	8.3 %
250-100 m.	22.0 %
500-250 m.	67.2 %
750-500 m.	1.0 %
1000-750 m.	0.7 %

These percentages are calculated from the total number of eggs in each net haul, corrected to make the numbers comparable. The numbers are very greatly influenced by the great abundance of eggs at St. 540. At this station the sounding was 510 m., so that the deepest net fished reached to 10 m. from the sea-bottom. It suggests a concentration of eggs near the bottom and a possible explanation of their relative paucity in our catches as a whole.

If the eggs are laid at or near the bottom, their occurrence in the surface nets might easily be accounted for by surface mixing of the water column, which in the Bransfield Strait region is known to be particularly effective.

Rustad (1930) referring to *Thysanoessa macrura* suggested that spawning in that species might take place below 400 m., and that eggs and sexually mature animals might be concentrated in circumscribed shoals. He thought it unlikely, however, that "a surface form like *Euphausia superba* would spawn in deep water". Ruud (1932) discounted the explanation of circumscribed shoals and, referring to *E. superba*, postulated the hypothesis that it spawns close to, or right under, the drifting ice. In a later paper Rustad (1934, p. 36) replies to Ruud's criticism and states "that the physical conditions in the deeper layers, as compared with those right under the ice should be unfavourable to the spawning and development of the youngest larvae, is hard to see. The chief difference is found in the salinity but this seems to be of less importance, our finds demonstrating that the larvae may develop at the higher salinity in the deeper layers; nor does the smaller content of oxygen seem to be unfavourable."

Rustad admits that he has not sufficient material to get a trustworthy idea of the distribution of the eggs and points out the limitations due to making only two vertical net hauls—the lower from 400 m.—in the interpretation of his results.

If eggs of *E. superba* occur in abundance in the proximity of drifting ice, it is rather surprising that so very few have been taken over a period of four years in the surface nets at stations made by the vessels of the Discovery Committee at the edge of, or actually in, pack-ice. Many of these stations were made at a time of year when *E. superba* is known to spawn, and if the number of eggs at St. 540, for instance, is typical of a spawning region the eggs could not fail to have been conspicuous in the plankton of the surface nets.

From discussion with Dr T. J. Hart it is learned that in his examination of the samples analysed for his Phytoplankton Report (Hart, 1934) he did not find any eggs recognizable as belonging to *E. superba*. The samples were from 50-cm. vertical nets (N 50 V) fished from 100 m. to surface, and, as the Report effectually demonstrates, used very frequently and over a wide area in the Antarctic. This indication of distribution of eggs in other than the first hundred metres, although admittedly negative, is based on such a large number of observations that it cannot be neglected.

Evidence in favour of deep spawning, additional to that supplied by the vertical distribution of the eggs themselves, is the occasional occurrence of fully adult animals in the deep hauls of the 70-cm. vertical nets. It should be emphasized that this net, like others, is selective in its fishing, and it is unusual to find adults of *E. superba* in it at any time. That they should be found deep down at the same time as eggs are taken, as indicated in Table III, leads one to infer that their occurrence at these depths is connected with spawning. Their condition as regards maturity also indicates that departure from the surface is associated with the deposition of eggs. The capture, referred to on p. 17, of ninety-five adults including many gravid females in a 250–100 m. haul lends still further support to the hypothesis of deep spawning in this species, and the fact that they were the only adults to be taken in any of the vertical or oblique nets hauled at this station is in favour of Rustad's idea that the animals congregate in circumscribed shoals for spawning.

It is remarkable that comparatively few eggs have been found in the samples analysed, and although Rustad's suggestion of circumscribed shoaling "and the consequent concentration of the eggs in relatively small areas" may be partly the reason I do not think that it is completely satisfactory. *E. superba* must be reproduced in immense numbers to hold the key position it has in the ecology of Antarctic life. The yield of the 70-cm. vertical nets, with the possible exception of those at St. 540, is surely not indicative of the normal concentration.

Is it possible that the development of eggs of *E. superba* takes place in water which is deeper than the lower limit of the vertical nets and that the eggs obtained are the scattered product of dispersal of a much greater mass situated in still deeper water? It may be that in this species the eggs, when laid, usually sink below 1000 m., and that the great abundance at St. 540 is due to the net coming within 10 m. of the sea-bottom

at a place of concentration where eggs are in somewhat shallower water than is usual.

Much more positive evidence is required on this problem before any definite solution can be put forward; conclusions drawn purely from negative evidence or from outstanding exceptions to the normal are very apt to be misleading, if not altogether wrong.

TIME OF SPAWNING

It is possible to get information about the duration of spawning in at least two ways. The first by observation of adults for indication of sexual maturity, and the other by consideration of the records of eggs in the plankton. It is not proposed in the present paper to deal with the first method beyond referring to the spawning of females in aquaria on the ship. The earliest record of this is on December 21 in the season 1930-1, and it is followed by another almost a month later on January 19. The latest record of eggs hatching is on February 10 in the season 1929-30. There is, then, from this source evidence of spawning taking place over about seven weeks at the height of the southern summer.

Conclusions based on the presence of eggs in the plankton involve the assumption that the time between the laying of eggs and the development into Naupliar and Calyptopis forms is very brief. The occurrence of all stages of development up to the clearly distinguishable 1st Nauplius in eggs in one catch, and the fewness of 1st and 2nd Nauplii in any of the catches, suggest that this is probably the case. Table XXXIX shows in half-monthly periods for the years 1928-31 the time at which eggs were found.

Table XXXIX. *Showing the half-monthly periods in which eggs have been found*

Season	1927-8	1928-9	1929-30	1930-1
Nov. 1-15	—	—	X	—
16-30	—	—	X	—
Dec. 1-15	—	—	—	—
16-31	—	X	X	X
Jan. 1-15	—	—	—	X
16-31	—	—	—	—
Feb. 1-14	—	X	X	—
15-28	X	X	—	X
Mar. 1-15	—	—	—	X

In the season 1927-8 there were no observations before February, but from the latter half of this month there is one record of eggs. In the season 1928-9 eggs were found between the second half of December and the second half of February, in the 1929-30 season between the first half of November and the first half of February and in the 1930-1 season between the second half of December and the first half of March. The longest period of spawning in one season is three and a half months, and for all the seasons under consideration the range is four and a half months. In the 1930-1 season the station from which the first eggs were recorded was not more than 120 miles distant

from the station nearly three months later at which the last eggs were found, so that the extended egg-laying period cannot be attributed to great difference in the locality from which the plankton samples were taken. In *E. superba*, therefore, it may be concluded from the available evidence that spawning is not restricted to one short period but is diffused over most of the months of the southern summer. There are indications that the greatest production of eggs is in November–December, but as regards abundance a distorted impression is obtained because certain plankton stations were taken at times and places close to each other while others were in these respects spaced widely apart.

NAUPLII

It is not possible to come to any definite conclusion regarding distribution of Nauplii when dealing with such small numbers as were found in our plankton samples. Both 1st and 2nd Nauplii were taken only at stations from which eggs were also recorded, so that the general remarks regarding the regional distribution of eggs apply equally to the Nauplii.

Both the 1st Nauplii were found below 100 m., the one in the 250–100-m. net and the other in the 750–500-m. net. It may be noted, too, that both Ruud's records are from nets fishing in subsurface water.

At three stations the 2nd Nauplii were in the 250–100-m. net, at three in the 500–250-m. net, and the remaining one was in the 750–500-m. net. There is no record from above 100 m. At two of the three stations where the Nauplii occurred in the 250–100-m. net eggs were found in the shallower nets, and it is possible that the Nauplii developed from such eggs.

As mentioned above, the rarity of 1st and 2nd Nauplii and the smallness of the number where records exist may indicate that these stages are passed through very rapidly in this species, as in other euphausiids where the development is known (*vide* Lebour, 1926 c, pp. 520, 521).

In the 1929–30 season all the 2nd Nauplii were taken in the second half of November, and in the 1930–1 season in the latter part of December. They were not found outside the range of the spawning period.

METANAUPLIUS

REGIONAL DISTRIBUTION

The distribution of the bulk of the Metanauplii differs in a marked manner from that of the eggs. The latter were concentrated within the Bransfield Strait, but, with the exception of those taken at St. 639, all the Metanauplii were taken north of the ridge formed by the Scotia Arc, and the exception accounts for two only out of a recorded total of over 4000 of this stage. Within the area of their distribution in the Scotia Sea this stage is found in the north-east at St. WS 197, not far distant from South Georgia. At this station 115 Metanauplii were taken between 1000 and 750 m. In the north-west they were found as far north of the South Shetlands as the vicinity of the Antarctic convergence (St. 646) from surface down to 500 m. to the number of fifty-six. The

greatest concentration of larvae was at St. 647, the one before that just mentioned; here 4279 Metanauplii were taken. The distribution of the stations where Metanauplii were taken is shown in Fig. 32.

VERTICAL DISTRIBUTION

The majority of the larvae belonging to this stage were found in the two deepest nets between 500 and 1000 m., although their occurrence is recorded also in the four upper nets at certain stations. At St. 647, where the larvae occurred in greater abundance than at all the other stations added together, they are entirely confined to depths between 500

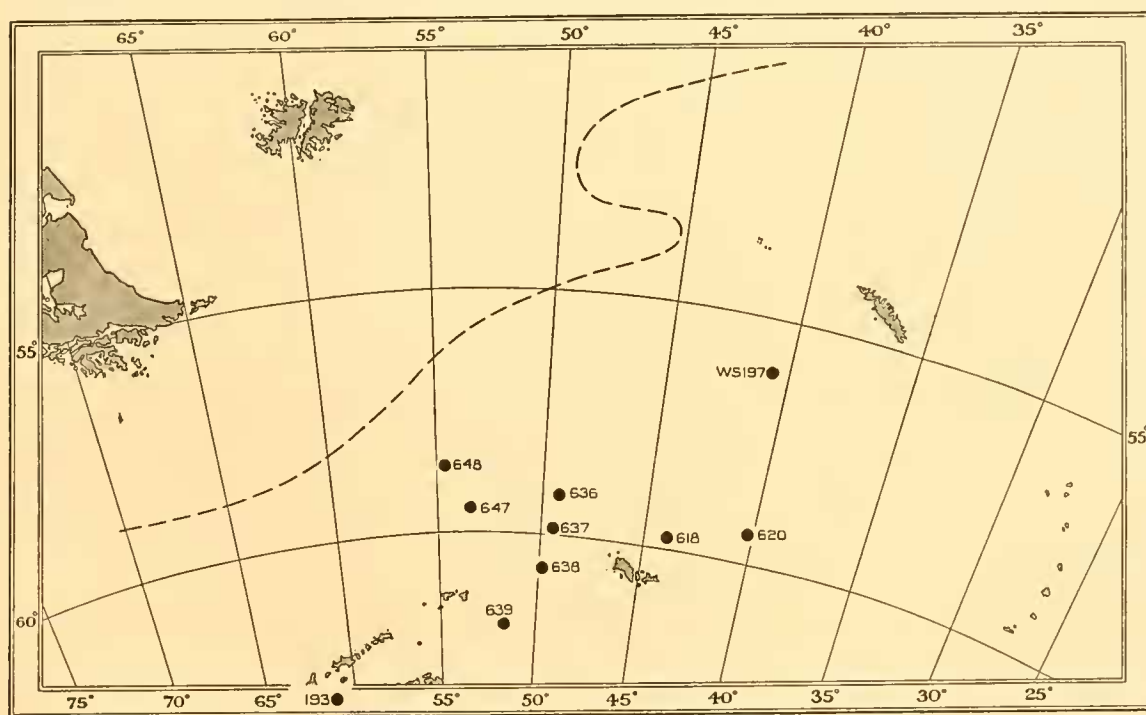


Fig. 32. Distribution of Metanauplius of *Euphausia superba*.

and 1000 m. In areas of open water away from the influence of the ridge of the Scotia Arc, and, in the case of St. 648, away from the influence of the Antarctic convergence, the larvae are entirely restricted to depths below 500 m. It is at such depths that the bulk of Metanauplii are found, and it is important to consider the conditions of their environment.

They are found in the warm deep water and not in cold Antarctic surface water. The properties of this warm deep-water layer are described by Deacon (1933, pp. 222 *et seq.*), and it is not necessary to recapitulate them here beyond pointing out that he states that the depth of the maximum temperature in 57° 30' S is 600 m. and of maximum salinity 700 m., and that the usual component of movement is from warm to cold regions and not from cold to warm.

Now if the temperature range within which Metanauplii were taken is examined, it will be seen that although the larvae are occasionally found in water of temperature below 0° C. they apparently favour the warmer water. Thus at St. 647 the range is be-

tween 1.34 and 2.01°C. , at St. WS 197 it is 1.33 – 1.27°C. , and with like positive temperatures for Sts. 618, 620, 636, 637 and 648. With regard to the last station, at which the larvae were found in each of the four nets from surface down to 500 m., it may be that the warm surface temperature, due to the proximity of the station to the convergence, produced the same favourable conditions for spawning and subsequent development as are more generally to be sought for in the warm deep layer below 250 m.

The significance of the vertical distribution of the Metanauplii is considered in conjunction with that of later larval forms on p. 163.

Later stages of development were present at all the stations where Metanauplii occurred, and it is interesting to compare their vertical distribution with that of the Metanauplii. In this comparison Sts. 639 and 648 have been regarded as exceptional and the distribution of the larvae taken there is not represented in Fig. 33. At the former station two Metanauplii were found, both in the surface net, and at the latter this stage was present from the surface down to 500 m., with greatest concentration between 100–

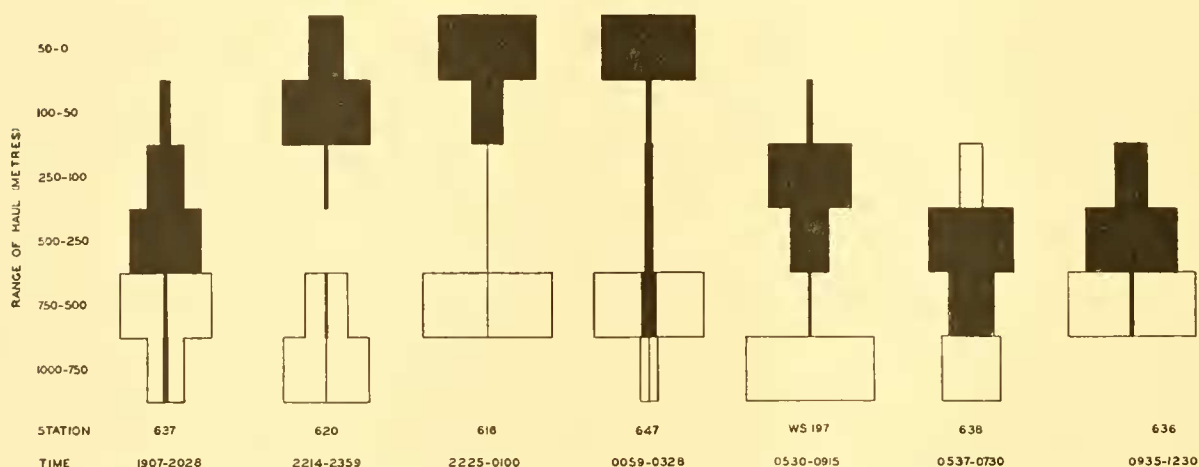


Fig. 33. Diagram showing the vertical distribution of the Metanauplius and later stages of development at the stations indicated. Areas shown in outline represent the Metanauplius, areas in black represent later stages.

50 m. In the remaining seven stations, as shown in Fig. 33, the Metanauplii are concentrated in the lowest nets fished. With the exception of two individuals all are in the 750–500 m. and 1000–750 m. nets. It will be seen that there is considerable variation in the vertical distribution of the older larvae and that this can be connected with the time of day at which the net hauls were made. The stations have been arranged in a sequence from midday to midday, the first starting at 1907 and the last finishing just after midday. The figure shows that in the larvae of *E. superba* subsequent to the Metanauplius stage there is a definite diurnal migration, so that during the hours of darkness they are concentrated between the surface and 100 m., whereas at other times they are massed at 500–250 m. The vertical migration of larvae will be referred to more fully later; it is sufficient here to mark the contrast between the behaviour of the Metanauplius and subsequent larval stages.

Ruud (1932, p. 33) says: "We only find larvae in any quantities in our samples at the stage when they begin to feed, i.e. the first Calyptopis stage (Taube, 1915). The younger larvae would naturally be found with the eggs." With respect to the last statement the present observations on the vertical distribution of the Metanauplius furnish very favourable evidence for the hypothesis that the eggs are to be found in deep water rather than at the surface.

TIME OF OCCURRENCE

All the Metanauplii were taken during the months of February, March and April and, while it is possible that about the middle of April may be the latest time for the occurrence of this form, the range in the other direction must be extended considerably beyond the date of the earliest record. It will be seen presently that there is an isolated record of a 2nd Calyptopis in the first half of November, which would indicate a period for the production of Metanauplii prolonged to at least five and a half months. But if this 2nd Calyptopis be regarded as an unusual exception—and that this may be so is indicated by there being no record of 2nd Calyptopis again until two and a half months later—then the normal time of occurrence of Metanauplii may be reduced to a period of about three months, extending from mid-January to mid-April in the second half of the southern summer.

CALYPTOPIS STAGES, FURCILIA STAGES AND ADOLESCENTS

REGIONAL DISTRIBUTION

It has been mentioned in the Introduction to this paper that the 70-cm. vertical nets yielded the main supply of earlier developmental forms and the 1-m. nets older larvae and adolescents. In discussing the distribution of stages subsequent to the Metanauplius it is convenient to classify the material examined in three divisions as follows:

Material caught in the 70-cm. nets.

Material obtained during the circumpolar cruise.

Material caught in the 1-m. nets.

Of these three divisions the first is concerned mainly with first season larvae, that is to say larvae taken during the summer season in which they were hatched; and the third division deals with second season forms, including late Furcilia and adolescents, hatched in the summer previous to that in which they were caught. The circumpolar cruise was made chiefly in the winter months and only material from the 1-m. nets was examined. As regards both time of year and state of development the larvae in the second of the above sections are placed intermediately between those of the other two sections.

MATERIAL CAUGHT IN THE 70-CM. NETS

In the discussion of the 70-cm. net catches the stations have been divided into the following areas:

- (1) Falkland Islands to South Georgia.
- (2) South Georgia surveys.

- (3) South Georgia to South Sandwich Islands.
- (4) Scotia Sea.
- (5) Drake Strait.
- (6) Bransfield Strait surveys.
- (7) Palmer Archipelago and Bellingshausen Sea.
- (8) East of South Georgia (ice-edge stations).
- (9) Weddell Sea.

For each area the groups of observations have been arranged with reference to the southern summer according to the time of year during which they were made and not in strict chronological order.

(1) Falkland Islands to South Georgia

Stations	Year	Time of year
(a) WS 251-256	1928	August
(b) WS 314-320	1928	December
(c) WS 137-143	1928	February
(d) WS 518-526	1930	February-March
(e) 655-659	1931	March
(f) WS 427-433	1929	April-May

(a) August 1928 (Sts. WS 251-256). Fig. 34.*

Only one larva was recorded at St. WS 255, west of the Shag Rocks: it was a *Furcilia* 6.

(b) December 1928 (Sts. WS 314-320). Fig. 35.

No larvae were taken.

(c) February 1928 (Sts. WS 137-143). Fig. 36.

The first three stations were made in sub-Antarctic water; at the last of these, St. WS 139, four *Calyptopsis* were found in the 500-250 m. net in temperatures of 2.66-3.09° C. At the surface at this station the temperature was 6.15° C. The larvae were carefully examined as it was considered unusual to get *E. superba* to the north of the Antarctic convergence, but they were undoubtedly this species. One *Calyptopsis* 1 and one *Calyptopsis* 2 were found at St. WS 141, 250-100 m., and one *Calyptopsis* 3 at 500-250 m.

(d) and (e) February-March 1930 and March 1931 (Sts. WS 518-526 and 655-659). Figs. 37 and 38.

No *E. superba*.

(f) April-May 1929 (Sts. WS 427-433). Fig. 39.

Larvae were taken at the first station only, situated between the north-west end of South Georgia and the Shag Rocks, and then only in small numbers, five in all representing *Furcilia* 3, 4 and 5.

In the Falkland Islands-South Georgia region larvae occur, but in small quantity, from the Antarctic convergence eastwards to South Georgia. A late *Furcilia* was obtained early in the season and *Calyptopsis* and early *Furcilia* after the new year in the second half of the southern summer.

* In this and in the subsequent distribution charts the larger circular marks indicate stations at which krill was found. The smaller marks indicate stations where the nets under consideration were examined with negative results.

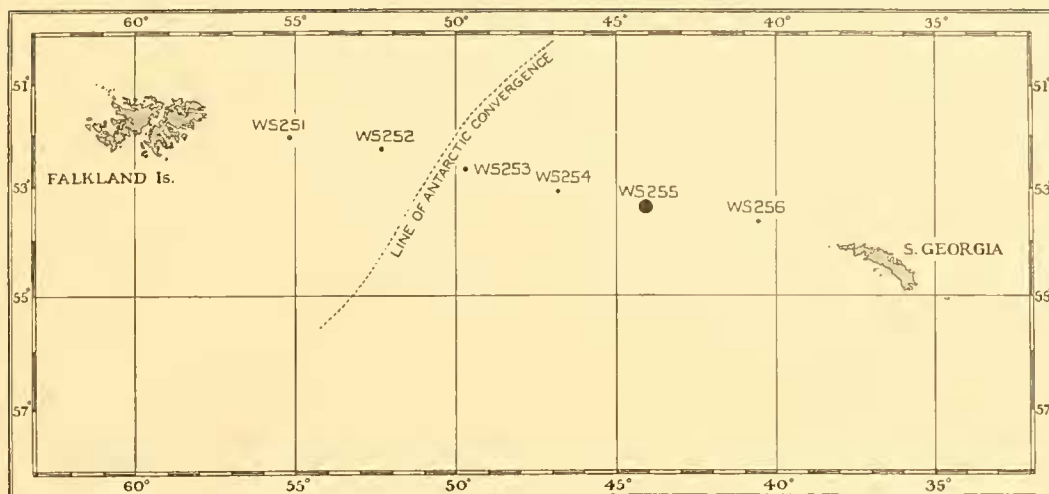


Fig. 34. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), August 1928.

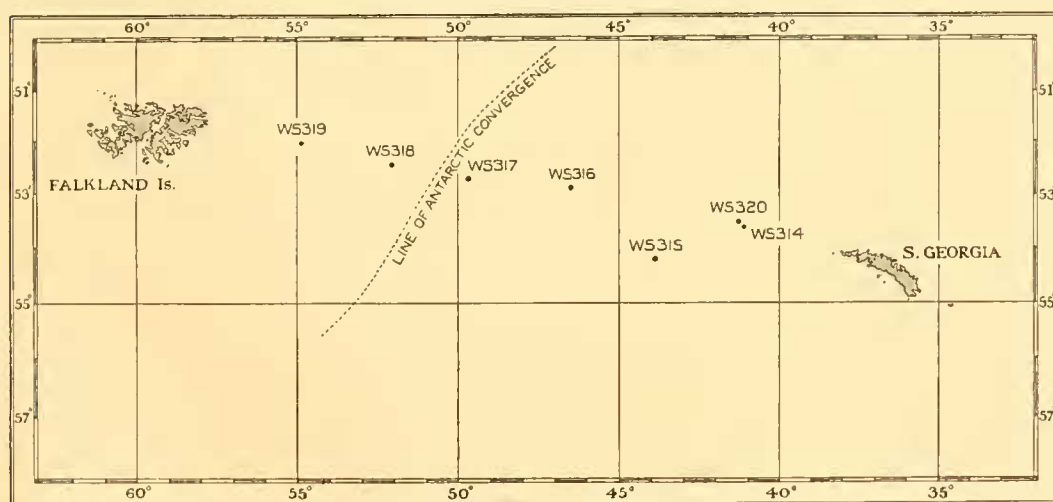


Fig. 35. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), December 1928.

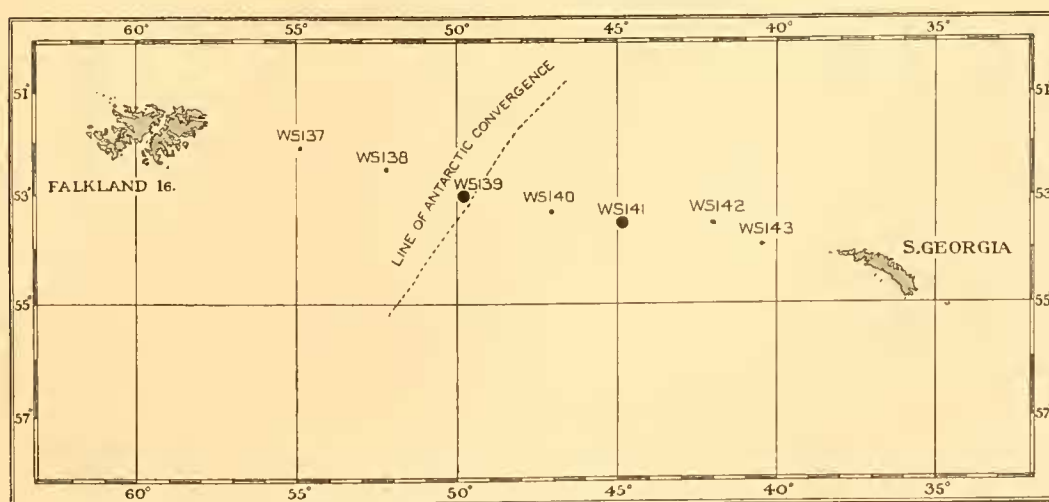


Fig. 36. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), February 1928.

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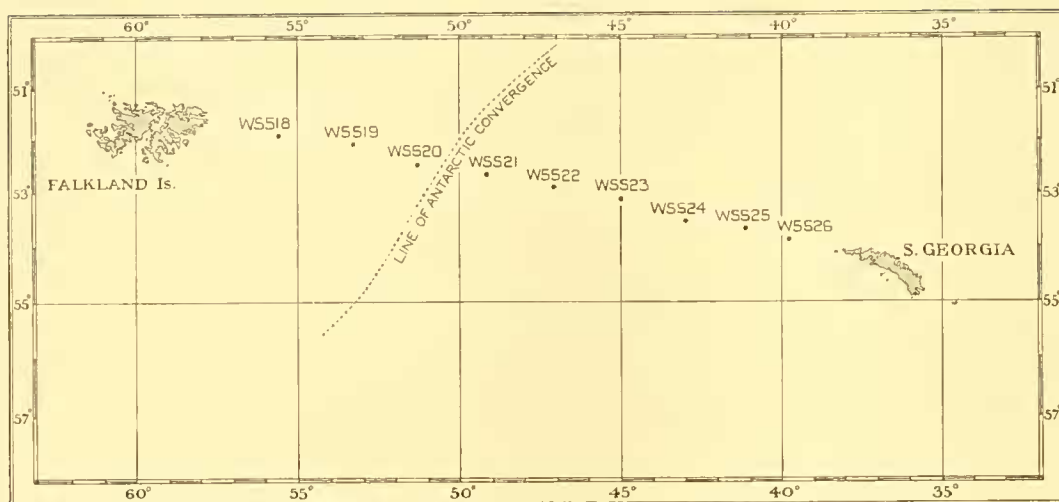


Fig. 37. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), February–March 1930.

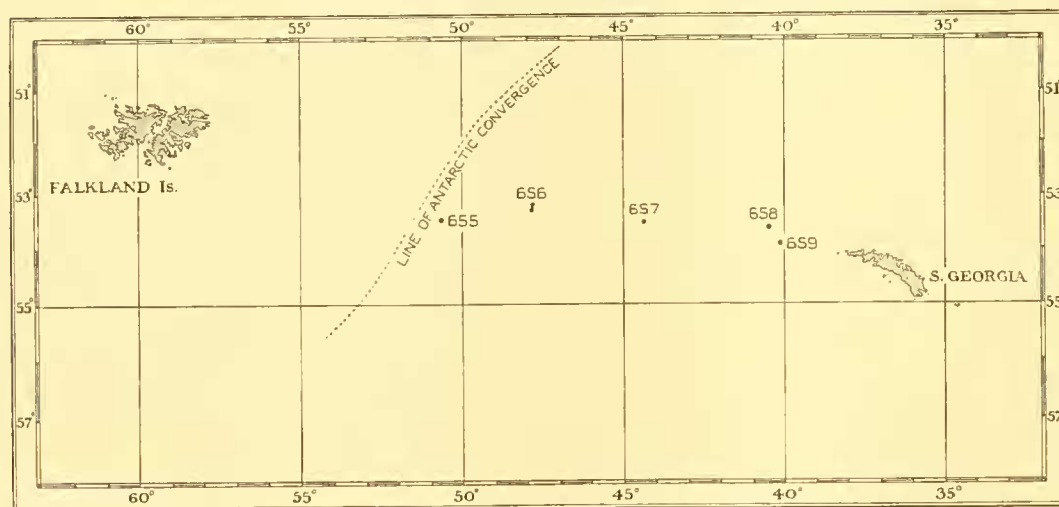


Fig. 38. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), March 1931.

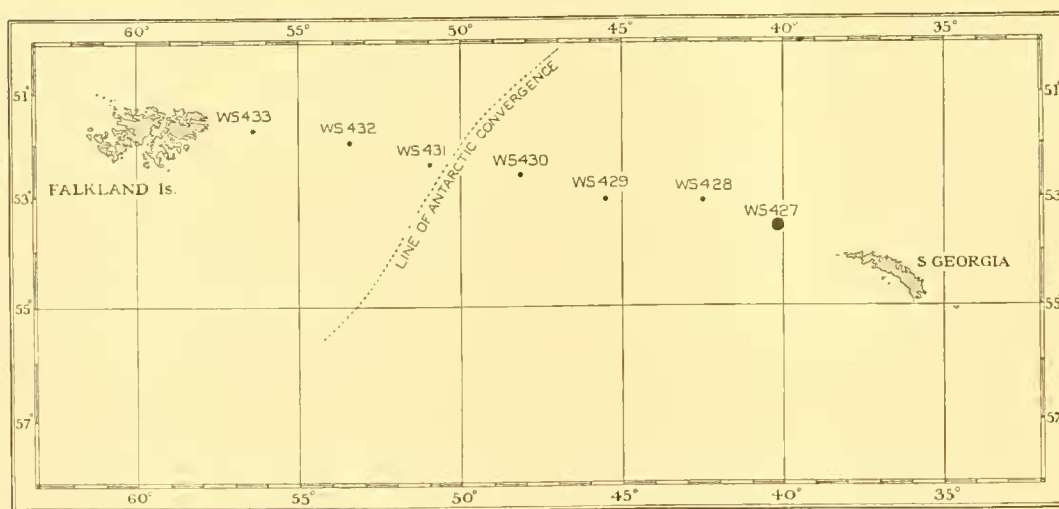


Fig. 39. Distribution of young *Euphausia superba* between Falkland Islands and South Georgia (70-cm. net hauls), April–May 1929.

(2) South Georgia surveys

Stations	Year	Time of year
(a) WS 257-296	1928	August-September-October
(b) 475-525	1930	November-December
(c) WS 321-365	1928-9	December-January
(d) 300-358	1930	January-February
(e) WS 144-195	1928	February-March
(f) WS 567-575	1931	March
(g) WS 417-426	1929	April
(h) 393	1930	May

(a) Survey of August-September-October 1928 (Sts. WS 257-296). Fig. 40.

As shown in Fig. 40 krill was present at several stations in this survey. All the larvae belonged to the previous year class and with the exception of one adolescent at St. WS 282 and WS 295 all were in the Furcilia 6 stage. The number of larvae recorded is remarkably small, never more than three at any one station.

(b) Survey of November-December 1930 (Sts. 475-525). Fig. 41.

With the exception of one Calyptopis 3 at St. 477 all the young krill from this survey belonged to the previous year class and were either Furcilia 6 or small adolescents. As in the previous survey the number of larvae recorded is very small except at the innermost station near Bird Island where 169 were found. The 1-m. net hauls, however, give a better indication of the abundance of the later and larger developmental forms. The majority of the records are confined to the two uppermost nets, but it is interesting to note that there are two from 1000-750 m. net hauls. The larvae do not show any indication of restriction to the areas beyond the shallow coastal water, and the largest number taken was close inshore. It is likely that this distribution is intimately bound up with the presence of pack-ice in the vicinity of South Georgia during this survey and just before it was made. The predilection of adolescents for the vicinity of pack-ice will be demonstrated later; it is mentioned here to give a possible explanation of larvae so close inshore.

(c) Survey of December-January 1928-9 (Sts. WS 321-365). Fig. 42.

No larvae were caught during this survey. The only evidence of the presence of *E. superba* was one egg taken at St. WS 323, the first deep-water station near Bird Island.

(d) Survey of January-February 1930 (Sts. 300-358). Fig. 43.

The stations at which larvae were obtained are shown in Fig. 43. To demonstrate that practically all the larvae were taken at stations made in deep water the 250-m. contour has been inserted in the map.

The larval stages found were Calyptopis 1, 2 and 3 and Furcilia 1, 2 and 3, with Calyptopis 3 predominating. At one station (St. 356) gravid females were taken in the 250-100 m. net, but neither eggs nor stages younger than Calyptopis 2 were found in the plankton samples.

The larvae were fairly abundant in number with the maximum at St. 303, where 133 were taken. Ninety-nine were taken at St. 320, four other stations had more than twenty larvae, and eighteen stations had less than ten.

At one station or another where the young euphausians were taken the net hauls from surface down to 1000 m. yielded larvae, and although the 500-250 m. net appears to be the deep limit for the majority it is not so for all of them. There is no reason to suppose that the larvae from the deeper nets were dead specimens sinking to the sea-bottom, as it is easy to distinguish dead *E. superba* in the samples.

The occurrence of the larvae at stations made in water deeper than 250 m., as opposed to shallower water stations, may be connected with their vertical distribution. It has already been remarked

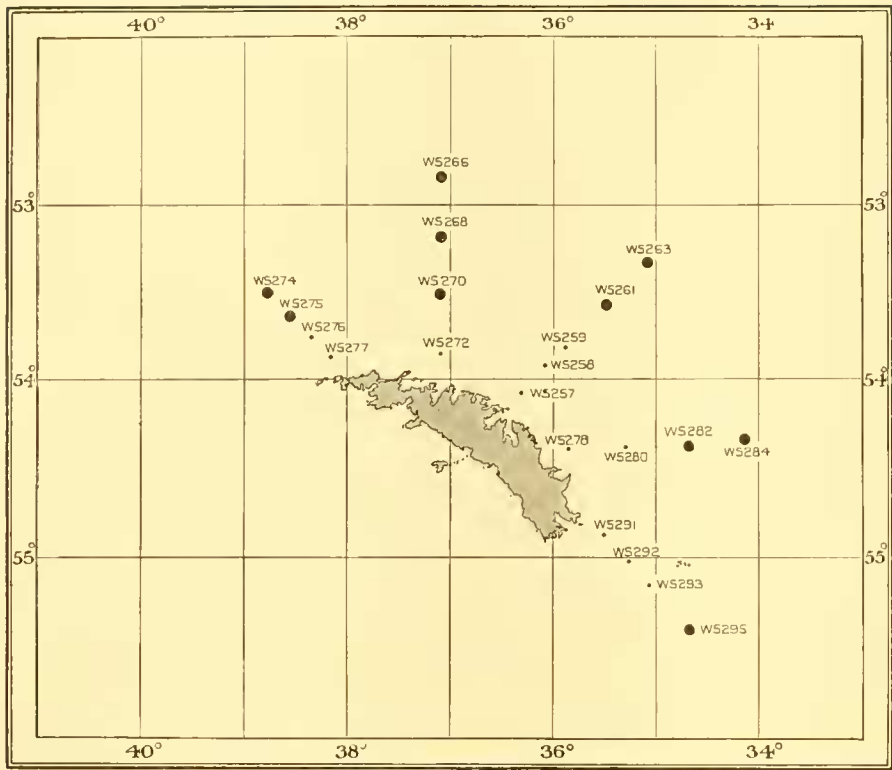


Fig. 40. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), August–October 1928.

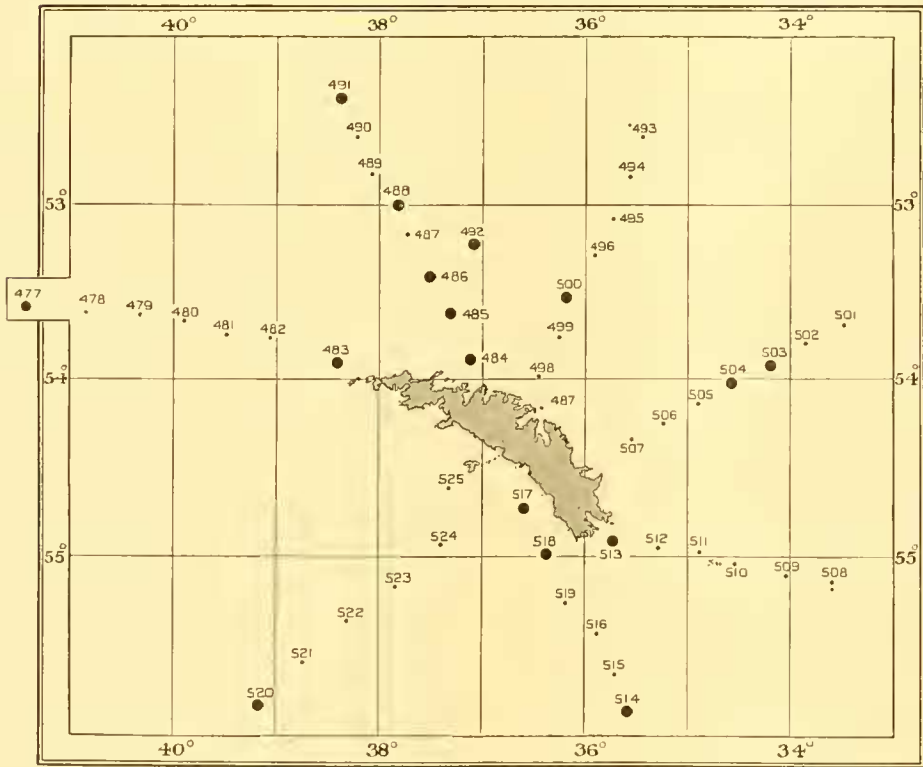


Fig. 41. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), November–December 1930.

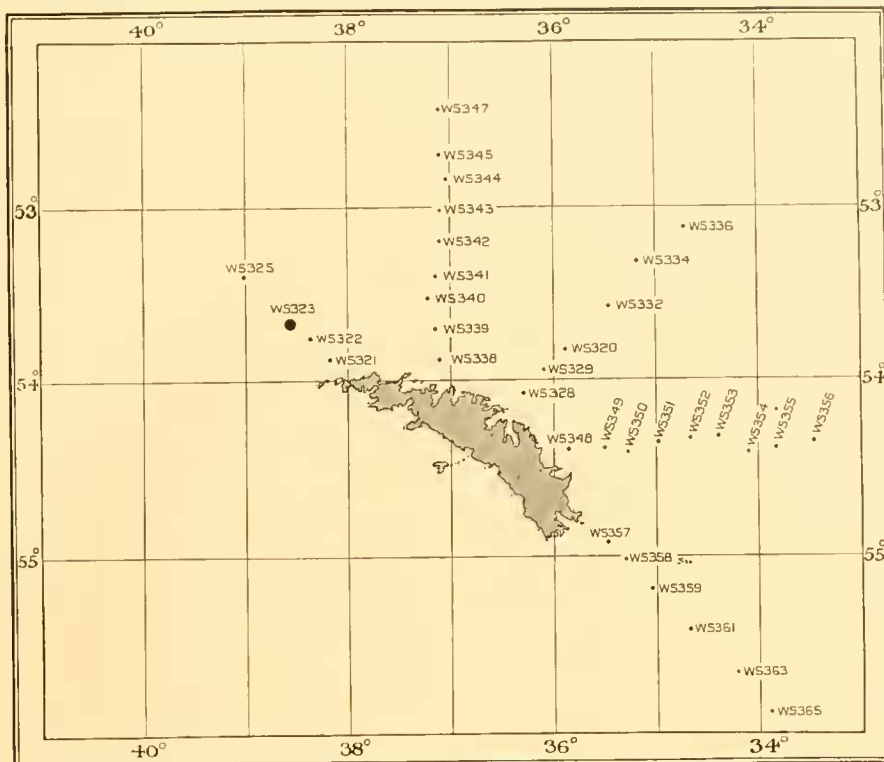


Fig. 42. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), December-January 1928-9

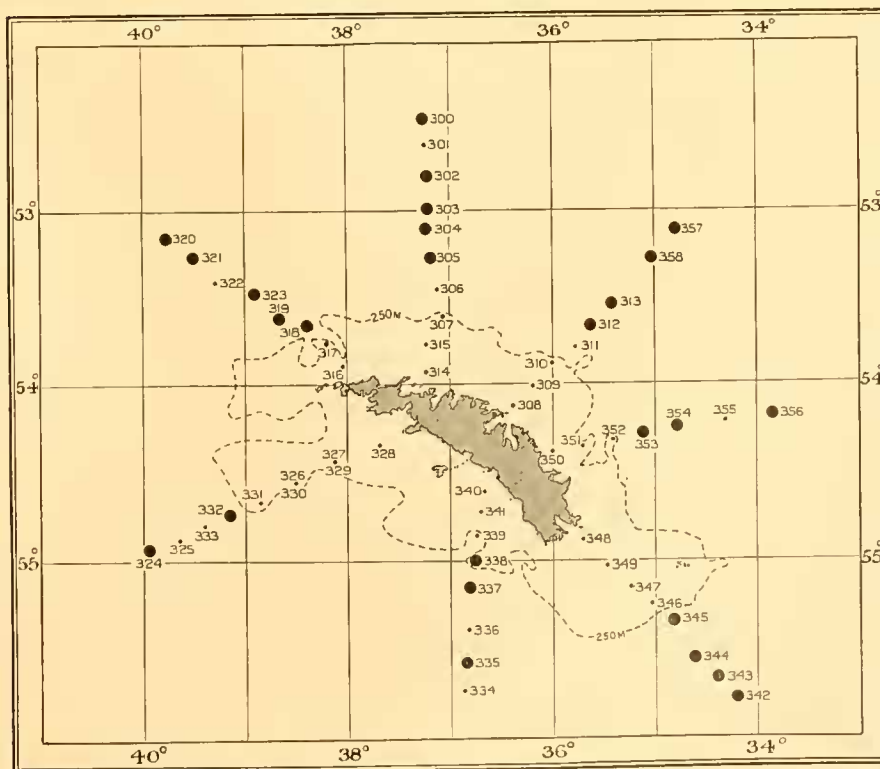


Fig. 43. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), January-February 1930.

(p. 115) that the larvae later in development than the *Metanauplius*, undergo a vertical migration diurnally through a column of water greater in depth than 250 m. That they should be absent from water shallower than 250 m. in this survey argues that for reasons connected with light intensity it is essential for them to have greater depths to recede to in the daytime. This will be dealt with in the section on vertical migration.

(e) Survey of February–March 1928 (Sts. WS 144–195). Fig. 44.

Very few larvae were taken during this survey; one *Calyptopis* 2 at St. WS 173 just beyond the shallow water on the Vakop Line and two *Calyptopis* 1 and 2 at St. WS 182 in the first deep-water station on the Clarke Rocks Line. It was noted above that one egg was taken at St. WS 147 in the 250–100 m. net. This station was on the edge of the continental shelf with a sounding of 274 m., but the previous station (WS 146), taken in almost the same position three days before, gave a sounding of 1096 m., so that both must have been on the very edge of the continental shelf.

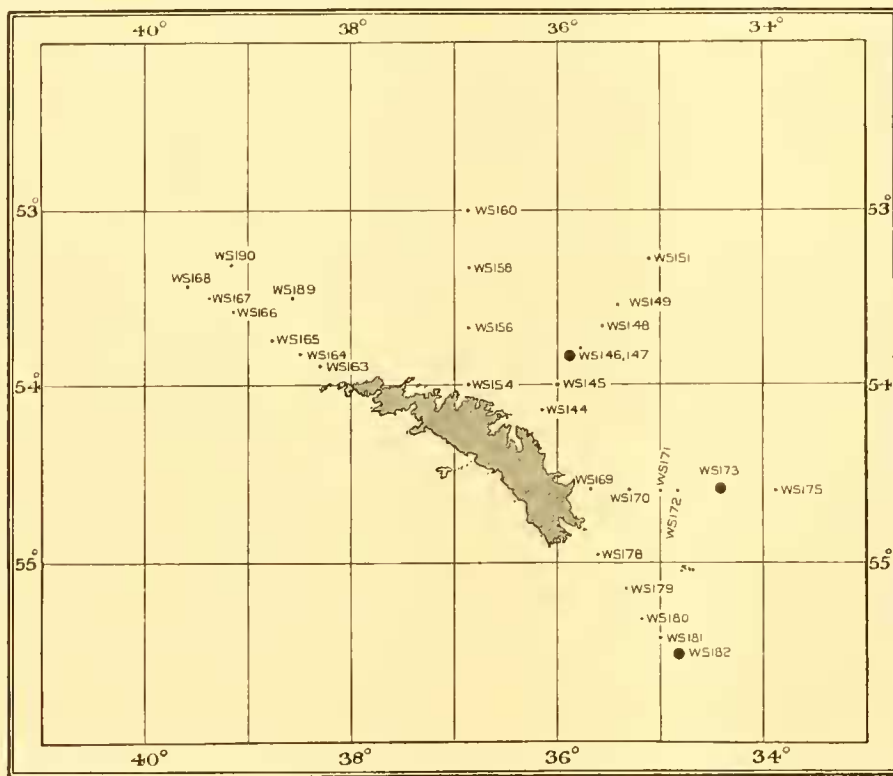


Fig. 44. Distribution of young *Euphausia superba*, South Georgia survey (70-cm. net hauls), February–March 1928.

(f) Prince Olaf lines, March 1931 (Sts. WS 567–575). Fig. 45.

Two lines of stations to the northward from Prince Olaf Harbour were made in March 1931, and at two stations, both in deep water, one *Calyptopis* 1 and one *Furcilia* 6 were recorded.

(g) South-west side of South Georgia, April 1929 (Sts. WS 417–426). Fig. 46.

No larvae were taken at any of the stations.

(h) East side of South Georgia, May 1930 (St. 393).

At this station four flights of nets, each from 300 m. to the surface, were made, but only one larva, a *Furcilia* 5, was taken.

Two points are made apparent by these surveys; first that *Calyptopis* and early

Furcilia stages are to be found chiefly in offshore deeper water, and secondly that older larvae, Furcilia 6 and adolescents, are not so restricted but come close to the island. It should be noted, too, that there is an ordered arrangement in the occurrence of the larvae. Up to the end of the year, that is until about the middle of the summer season, only larvae and adolescents of the previous year class are obtained. In the new year Calyptopis and early Furcilia appear, indicating that spawning must commence about the end of the year. From March onwards later Furcilia are obtained but with Calyptopis 1 still occurring.

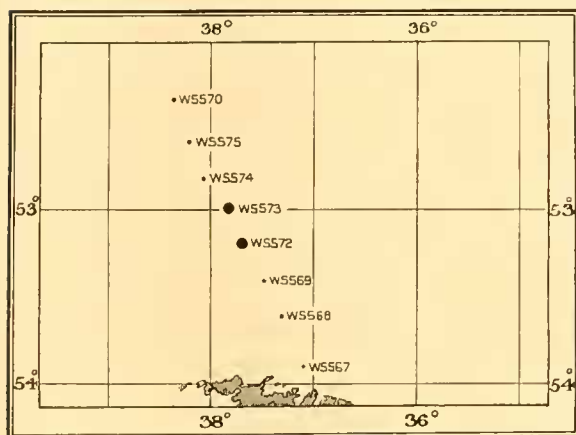


Fig. 45. Distribution of young *Euphausia superba*, Prince Olaf lines (70-cm. net hauls), March 1931.

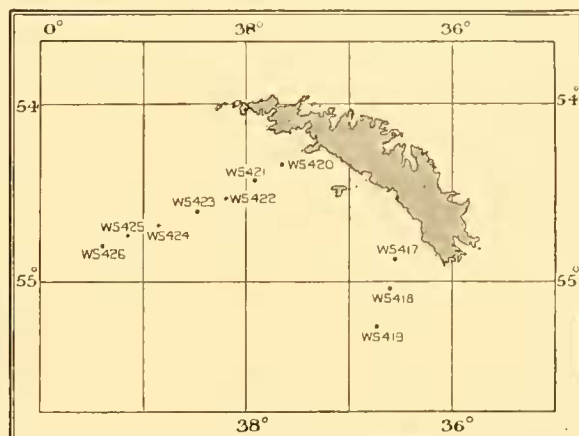


Fig. 46. Distribution of young *Euphausia superba*, south-west side of South Georgia (70-cm. net hauls), April 1929.

(3) South Georgia to the South Sandwich Islands, February–March 1930 (Sts. 360–369). Fig. 47

The line of stations from South Georgia to the South Sandwich Islands was made immediately after the completion of the South Georgia survey of January–February 1930 described above. It will be recalled that more larvae were taken during this survey than in any of the others carried out in that neighbourhood. This abundance was increased at the stations of the South Sandwich line. Larvae were taken at each of the six stations where the 70-cm. vertical nets were fished, and at most of these the numbers were greatly in excess of those in the net hauls of the above-mentioned South Georgia survey.

Sts. 360, 361 and 362 were made between South Georgia and the northernmost of the South Sandwich Group. At St. 360 one each of Calyptopis 3 and Furcilia 1, 2, 3 and 6 were taken; at

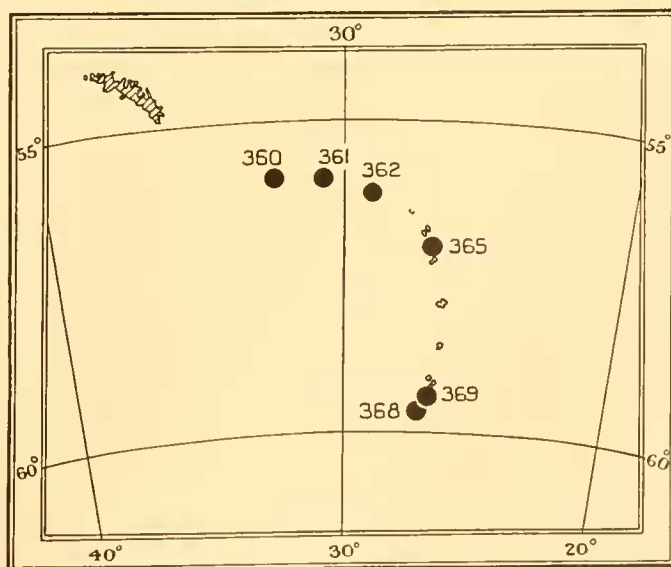


Fig. 47. Distribution of young *Euphausia superba*, South Georgia to South Sandwich Islands (70-cm. net hauls), February–March 1930.

St. 361 there were 339 larvae with *Furcilia* 1 predominating but with *Calyptopis* 2 and 3 and *Furcilia* 3 and 4 also present, and at St 362 there were 343 larvae, with *Calyptopis* 3 predominating but having in addition *Calyptopis* 2 and *Furcilia* 1, 2 and 3. All these stations were in water over 3000 m. deep, but all were in the vicinity of the ridge connecting South Georgia and the South Sandwich Islands.

St. 365 was situated between Visokoi and Candlemas Island. 601 larvae were taken there with *Calyptopis* 3 predominating. *Calyptopis* 1 and 2 and *Furcilia* 1 and 2 were present. At Sts. 368 and 369, both in the neighbourhood of Cook and Thule Islands, fifty and fifty-seven larvae respectively were taken, and at both stations *Furcilia* 1 predominated, but with *Calyptopis* 3 and *Furcilia* 2 and 3 also present.

The most notable feature in this line of stations is the increase in the number of larvae taken compared with that in the South Georgia area. The stages of development are in accordance with what was found in the South Georgia surveys. The record of *Furcilia* 6 so early in the year is noteworthy.

The larvae do not show an ordered arrangement in the degree of development from north to south, for at the first station where larvae are abundant *Furcilia* 1 predominates, at the next two to the south *Calyptopis* 1, and at the two southernmost *Furcilia* 1 again.

(4) Scotia Sea (Fig. 48)

	Stations	Locality	Year	Time of year
(a)	161-167 -170	South Georgia- South Orkneys- Elephant Island	1927	February
(b)	WS 374-381	South Georgia- South Orkneys- Elephant Island	1929	February
(c)	618-629	South Orkneys- South Sandwich- South Georgia	1931	February
(d)	633-638	South Georgia- South Orkneys	1931	March
(e)	372-375 WS 527-531	South Sandwich- Burdwood Bank	1930	March-April
(f)	WS 196-202	South Georgia- South Shetlands	1928	April
(g)	WS 203-209	South Shetlands- Burdwood Bank	1928	April

The stations in this section were all taken in the area bounded to the north, east and south by the Scotia Arc and on the west by the Drake Strait.

(a) South Georgia to the South Orkneys and Elephant Island, February 1927 (Sts. 161-170).

Vertical nets were fished at Sts. 160 and 161 between South Georgia and the South Orkneys, but only at the latter were larvae present. This station was situated about midway between the Shag Rocks and the South Orkneys, and at it eight larvae, all *Calyptopis* with the 2nd predominating, were taken. A single *Calyptopis* 2 was found at St. 167, the next vertical station made in the vicinity of the South Orkneys.

At St. 169, to the east of Clarence Island, the three Calyptopis stages and the 1st Furcilia were represented in a total of seventeen larvae, with Calyptopis 3 predominating.

(b) South Georgia to the South Orkneys and Elephant Island, February 1929 (Sts. WS 374–381).

At St. 376, midway between South Georgia and the South Orkneys, four adult male and two adult and gravid females were taken in the 750–500 m. net. At the next station to the south, St. WS 377, a single egg of *E. superba* was taken in the 250–100 m. net. Nothing was found at the two following stations, but at St. WS 380, midway between the Orkneys and Elephant Island, four eggs were found, two in the 250–100 m. and two in the 500–250 m. net. There were no larvae at St. WS 381.

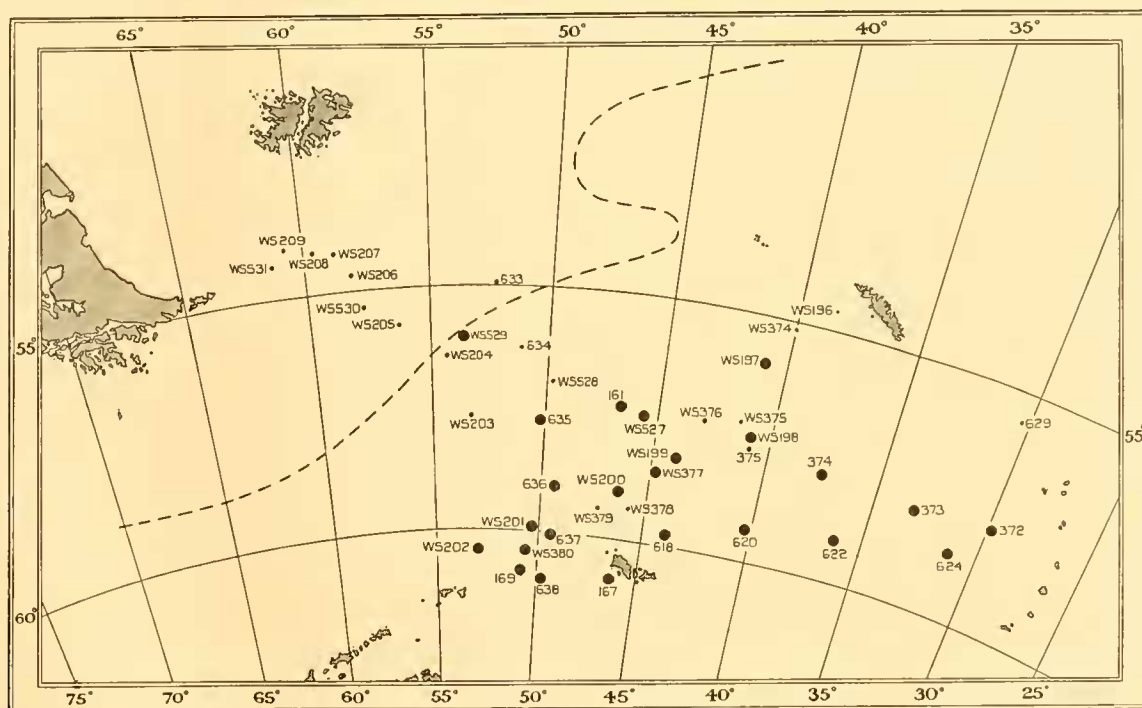


Fig. 48. Distribution of young *Euphausia superba*, Scotia Sea (70-cm. net hauls).

(c) South Orkneys to the South Sandwich Islands and South Georgia, February 1931 (Sts. 618–629).

Vertical nets were fished at Sts. 618, 620, 622, 624 and 629.

At St. 618, the first station on this line, situated to the north-east of the South Orkneys, there were 985 larvae distributed from the surface down to 750–500 m. Calyptopis 1 predominated, but there were present also Metanauplii, deep down, and Calyptopis 2. At this station also an egg was found in the 250–100 m. sample.

At St. 620, larvae, totalling 243, were found in all the nets down to 1000 m. with the exception of the 500–250 m. haul. Calyptopis 1 was again the most plentiful with few Calyptopis 2 and Metanauplii, the latter being entirely confined to the lowest nets.

At St. 622 the number of larvae was much reduced, only forty-two being taken. With the exception of one Calyptopis 2 all were in the Calyptopis 1 stage. No Metanauplii were obtained at this station.

At St. 624 only one larva, a Furcilia 1, was obtained from the quarter sample of the 70-cm. net analysed. Ten Furcilia 1, four Furcilia 2 and one Furcilia 3 were taken in the 1-m. net.

There were no larvae at St. 629, between the South Sandwich Islands and South Georgia.

Of these stations, all up to St. 626 were taken in the proximity of the pack-ice edge.

(d) South Georgia to South Orkney, March 1931 (Sts. 633-638).

St. 633, the first vertical station on this line, was situated to the eastward of the Burdwood Bank, and with the succeeding one was made in sub-Antarctic water. At St. 635, the first station south of the Antarctic convergence, twenty-eight larvae representing stages from Calyptopis 2 to Furcilia 3 were found, with Calyptopis 2 and 3 in greatest number. At St. 636 there were sixty-four larvae from Metanauplius to Furcilia 1, with Calyptopis 1 predominating. The Metanauplii were all in the 750-500 m. net, whilst the remaining stages were distributed between 100 and 750 m. An egg, Metanauplii and Calyptopis 1 were found at St. 637, the egg at 250-100 m., the Metanauplii at 1000-500 m. and the Calyptopis between 100 and 1000 m. In all 129 larvae were taken, with Calyptopis 1 in greatest abundance.

At St. 638 the number of larvae was smaller, fourteen being taken. This station was made midway between the South Orkneys and Elephant Island, and only Metanauplii and Calyptopis 1 were taken. The Metanauplii were eight in number, and with the exception of one in the 250-100 m. net were in the two lowest nets. The Calyptopis were found between 250 and 750 m.

The last station (St. 639) on this line is better considered with the Bransfield Strait Stations, as it is situated midway between the South Orkneys and Joinville Island.

(e) South Sandwich Islands to the Burdwood Bank, March-April 1930 (Sts. 372-375 and WS 527-531).

This line of stations traversed the Scotia Arc in a diagonal course from east to west, crossing the Antarctic convergence between Sts. WS 529 and WS 530. The Discovery II stations were made between March 18 and 21, and those of the William Scoresby between March 30 and April 5.

At the first station (372) Furcilia 5 was in greatest abundance, with Furcilia 2, 3, 4 and 6 present: there were forty-one larvae in all.

Furcilia 5 was again predominant at St. 373, there being twenty-seven of this stage out of a total of thirty-seven larvae. Furcilia 2, 3, 4 and 6 were represented.

At St. 374 Furcilia 4 was the predominant stage with twenty-three out of a total of sixty-one larvae in which Furcilia 2-6 were present.

Furcilia 5 was once again the principal stage represented in the last Discovery II station: Furcilia 2, 3, 4 and 6 were also present.

No less than 756 larvae, distributed between the surface and 500 m., were obtained at St. WS 527. The larvae have been described in another section of this paper, in which attention was drawn to the great variety of forms encountered. At this station, for the first time on this line, Calyptopis were present. Furcilia 2 was the principal stage, and in addition Furcilia 1, 3, 4, 5 and 6 were represented. No larvae were recorded from St. WS 528. At St. WS 529 101 larvae were taken with Furcilia 3 predominating and Furcilia 2, 4, 5 and 6 present.

Sts. WS 530 and WS 531 were in warm water and no *E. superba* were recorded.

(f) South Georgia to the South Shetlands, April 1928 (Sts. WS 196-202).

St. WS 196 was made in shallow water to the south-west of South Georgia and no larvae were taken.

At St. WS 197 Calyptopis and Furcilia 1 were taken in the upper nets and nothing but the Metanauplius in the lowest net. Down to 750 m. Calyptopis 1 was the principal stage and below that only the Metanauplius was obtained. There were 209 larvae altogether.

Very few larvae were obtained at St. WS 198, the three Calyptopis stages and Furcilia 1 being represented with the latter predominating in a total of nine.

There were sixty-two larvae at St. WS 199, of which Furcilia 1 was the most prominent; in addition Calyptopis 3 and Furcilia 2 and 3 were present.

At St. WS 200 there were 154 larvae, with Furcilia 1 again the principal stage and Calyptopis 3 and Furcilia 2 and 3 also present.

The number was reduced to twenty-nine at St. WS 201, with the same stages represented as before and the same principal stage.

At St. WS 202, to the north-east of Elephant Island, twelve larvae were taken in which Calyptopis 2 and Furcilia 1 and 2 were present with Furcilia 2 the principal stage.

(g) South Shetlands to the Burdwood Bank, April 1928 (Sts. WS 203–209).

This line was made immediately after that just described, and no larvae were taken.

The observations in the Scotia Sea emphasize the general and widespread distribution of *E. superba* larvae within that part which is south of the Antarctic convergence. The occurrence of the different developmental stages is broadly what would have been anticipated from the foregoing observations. In February, in three different seasons, Calyptopis 2 is the predominant stage, showing that spawning must have commenced at about the same time as was indicated in the South Georgia region. But although in February 1931 Calyptopis 2 predominated there is a reversion of predominance to the previous stage in a line to the westwards made in March 1931. In March–April 1930 Furcilia 2–5 are most prominent; in April 1928 there is a reversion of predominance to earlier stages. It is thus obvious that in the same season, but in different localities of the same area, there is quite considerable variation in the degree of development at comparable times. It also demonstrates that different stages may predominate at the same time of year in different years.

The series of stations 618–639 requires particular attention. At each of the vertical stations along the ice-edge, larvae were taken in considerable quantity, which diminished in amount from west to east. From St. 625 onwards no larvae were taken. Compare these results with those described by Mackintosh (1934, p. 128, fig. 45) for this line of stations. He states:

In February the 'Discovery II' returned to the South Sandwich region working stations along the ice-edge between the South Orkney Islands and the Sandwich Group. These stations (618–629) are shown in Fig. 45. The ice line had retreated very little since December but the plankton had changed to a much warmer type. . . . None of the very "cold" group was present but such warm water species as *Pareuchaeta*, *Pleuromamma* and *Euphausia frigida* were included in the catches. As the ship approached the South Sandwich Islands, however, signs of a "colder" plankton appeared. *Vanadis* occurred at St. 624 and *Diphyes antarctica* at Sts. 625, 626, 628 and 629.

That is to say that the young krill, though admittedly taken at the ice-edge, were obtained exclusively in the region of Mackintosh's "warmer" plankton. Mackintosh states that the presence of ice does not necessarily entail the presence of cold-water plankton. This is a point to be emphasized, that the presence of the larval krill at the pack-ice edge does not mean that it is a "cold" species. This is borne out by the line from South Sandwich to the Burdwood Bank in March–April, 1930. The whole of this line was in a region where conditions for the occurrence of "warmer" plankton were prominent, and at each of the stations excepting St. WS 528, young larvae were present in an abundance which was conspicuous at St. WS 527 and WS 529, where the water was even warmer than at the preceding stations.

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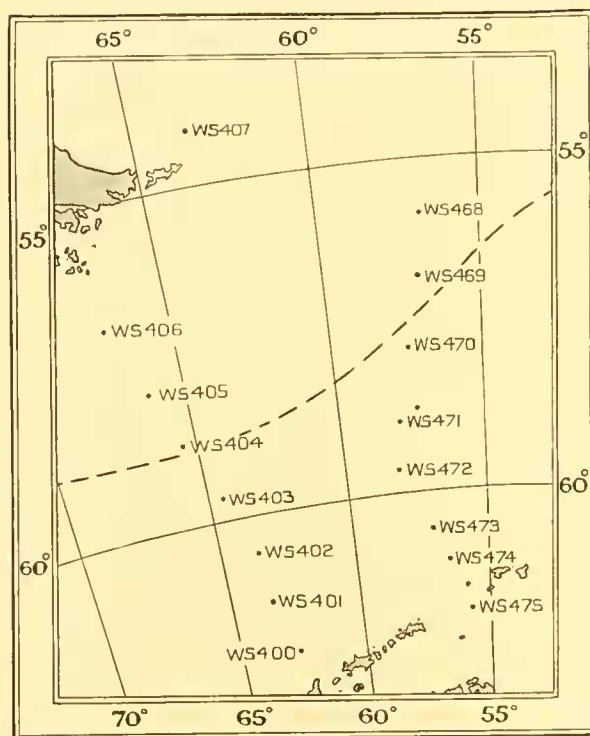


Fig. 49. Distribution of young *Euphausia superba*, Drake Straits (70-cm. net hauls), February and November 1929.

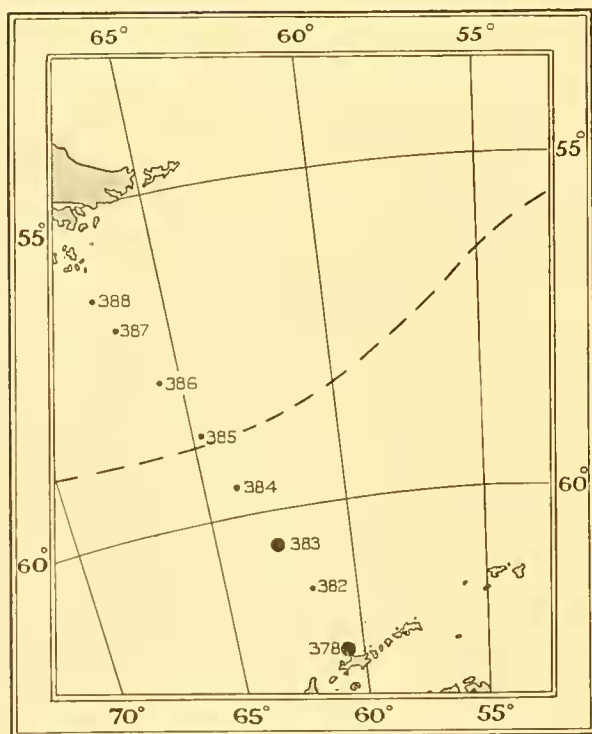


Fig. 50. Distribution of young *Euphausia superba*, Drake Straits (70-cm. net hauls), March 1931.

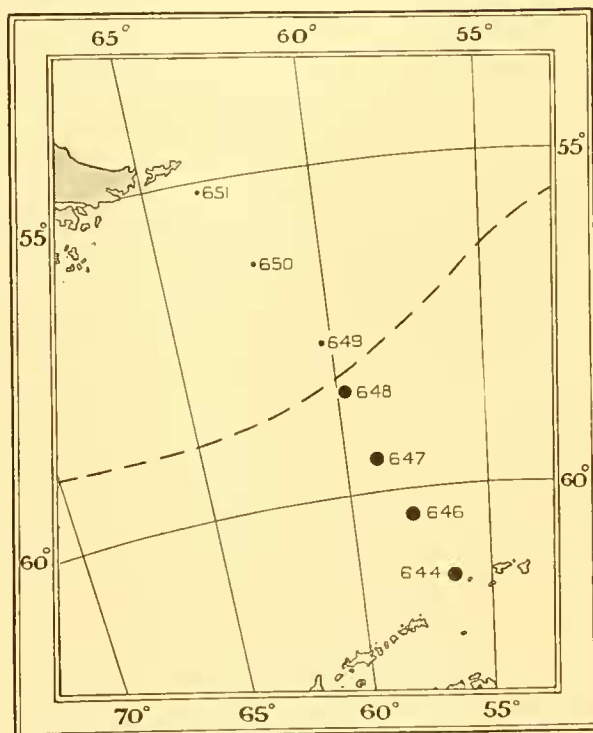


Fig. 51. Distribution of young *Euphausia superba*, Drake Strait (70-cm. net hauls), April 1930.

(5) Drake Strait

	Stations	Year	Time of year
(a)	WS 468-475	1929	November
(b)	WS 400-407	1929	February
(c)	644-651	1931	March
(d)	378-388	1930	April

(a) and (b) yielded no eggs or larvae (Fig. 49).

(c) March 1931 (Sts. 644-651). Fig. 50.

This line of stations was made rather to the east of the Drake Strait from a point west of Elephant Island towards Staten Island. Of seven stations at which vertical nets were fished four were south of the Antarctic convergence and at all of these eggs and larvae were taken.

At St. 644 a few eggs only were taken and at St. 646 eight Calyptopis 1 and 2, with the latter stage predominating. 5200 larvae representing Metanauplius, Calyptopis 1 and 2 were taken at St. 647. The Metanauplii, 4279 in number, were confined to the two lowest nets between 500 and 1000 m. The Calyptopis were distributed throughout the six nets with greatest concentration in the surface net.

There were eighty Metanauplii and Calyptopis 1 at St. 648, with the Metanauplii predominating. The conditions at this station have been mentioned above, p. 115.

No *E. superba* were taken at the remaining stations north of the Antarctic convergence.

(d) April 1930 (Sts. 378-388). Fig. 51.

This line of stations was made immediately after the completion of the combined Discovery II-William Scoresby line (4(e)), from the South Sandwich Islands to the Burdwood Bank. It will be remembered that in that line Furcilia 5 predominated in the east and Furcilia 2 and 3 in the west. Vertical nets were worked at eight stations in the present line. Four of the stations were south of the Antarctic convergence and the remainder in warmer water.

Larvae were taken at Sts. 378 and 383, the first and third stations of the line. There were few larvae at the former, eleven in all, representing the three Calyptopis stages with the 2nd predominating. Larvae were once again abundant at St. 383, 787 being taken between 50 and 250 m. The three Calyptopis stages and Furcilia were represented, with Calyptopis 3 predominating.

The Drake Strait lines are chiefly important for the yield of the Metanauplius stage which one of them presents. The regional occurrence of this larval stage has been mentioned previously (p. 114), and its preference for warmer water pointed out. At both lines of stations from which we have records of larvae the greatest concentration is to the northward rather than the southward, and in the warmer rather than the colder water. These concentrations are of larvae having young stages predominant, in the one line Metanauplius and in the other Calyptopis 3.

Both lines were made late in the summer season, yet such early stages as Metanauplius and Calyptopis 1 were still obtained, which shows that in this species, unless of course development is delayed in some of the young larvae, the time range of spawning is not restricted to a short, definite period.

(6) Bransfield Strait surveys

	Stations	Year	Time of year
(a)	WS 476-493	1929	November
(b)	537-555	1930	December
(c)	WS 382-399	1929	February
(d)	171-177	1927	February-March
(e)	639, 644	1931	March
(f)	193-209	1927	March-April
(g)	376-377	1930	April

(a) Survey of November 1929 (Sts. WS 476-493). Fig. 52.

Eggs were taken at several stations in this survey. They were in greatest abundance between King George Island and Trinity Land, where eighty-three are recorded from St. WS 480 at depths between 100 and 500 m.; at St. WS 477 there was one egg between 1000 and 500 m. At each of the stations in the middle line between Livingston and Astrolabe Islands eggs were taken in very small quantity, never more than five at any one station, in nets fishing between 250 and 950 m. None were found in the Smith Island to Brabant Island line, but four Nauplius 2 were recorded, one at St. WS 480 and the remainder in the middle line.

(b) Survey of December 1930 (Sts. 537-555). Fig. 53.

Eggs were taken at all the stations on the east line from Elephant Island towards Joinville and at the northernmost and southernmost but one of the King George Island to Trinity Land line. Nothing is recorded from any of the stations in the western line from Snow Island to Trinity Island.

(c) Survey of February 1929 (Sts. WS 382-399). Fig. 54.

Only four eggs were taken in this survey, three of them in two stations on the King George Island line and one at St. WS 394 in the vicinity of Deception Island.

(d) Survey of February-March 1927 (Sts. 171-177).

There was only one vertical net station near Cape Melville, King George Island, at which a *Furcilia* 1 was recorded.

(e) Survey of March 1931 (Sts. 639 and 644). Fig. 54 (inset).

St. 639, situated about midway between the South Orkney Islands and Joinville Island, yielded *Metanauplii*, the three *Calyptopsis* stages and *Furcilia* 2. It was at this station that the *Metanauplii*, two in number, were found in the surface net. *Calyptopsis* 1 predominated, there being 218 out of a total of 293 larvae.

At St. 644 near Elephant Island two days later, ten eggs only were taken.

(f) Survey of March-April 1927 (Sts. 193-209). Fig. 55.

At St. 193 at the west end of the Bransfield Strait between Smith and Trinity Islands, 120 larvae were taken with *Calyptopsis* 3 predominating and *Calyptopsis* 2 and *Furcilia* 1 also present.

There were 189 larvae taken at St. 194, with *Calyptopsis* 3 again predominating, and *Calyptopsis* 2, and *Furcilia* 1 and 3 present.

At St. 196, off King George Island, only two *Furcilia* 4 were taken; at St. 197 thirty-two larvae were taken in which *Calyptopsis* 2 and 3 and *Furcilia* 1, 2 and 3 were represented, *Calyptopsis* 3 and *Furcilia* 3 were most prominent. At St. 198 there were eighty-seven larvae with *Calyptopsis* 2 and 3 prominent and *Calyptopsis* 1 and *Furcilia* 1, 2, 3 and 4 present. There were fifty-nine larvae at St. 199 including *Calyptopsis* 2 and 3 and *Furcilia* 2, 3 and 4, with *Furcilia* 3 the most prominent. At St. 200, the last station on the King George Island line, three *Furcilia* 1 and 2 were taken.

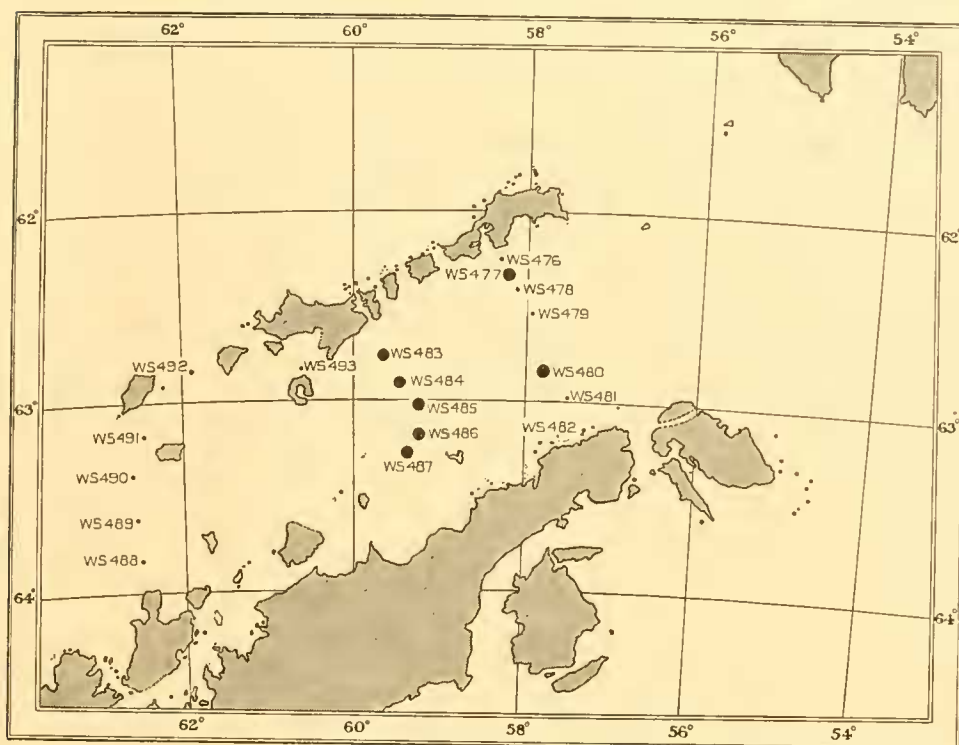


Fig. 52. Distribution of young *Euphausia superba*, Bransfield Strait survey (70-cm. net hauls), November 1929.

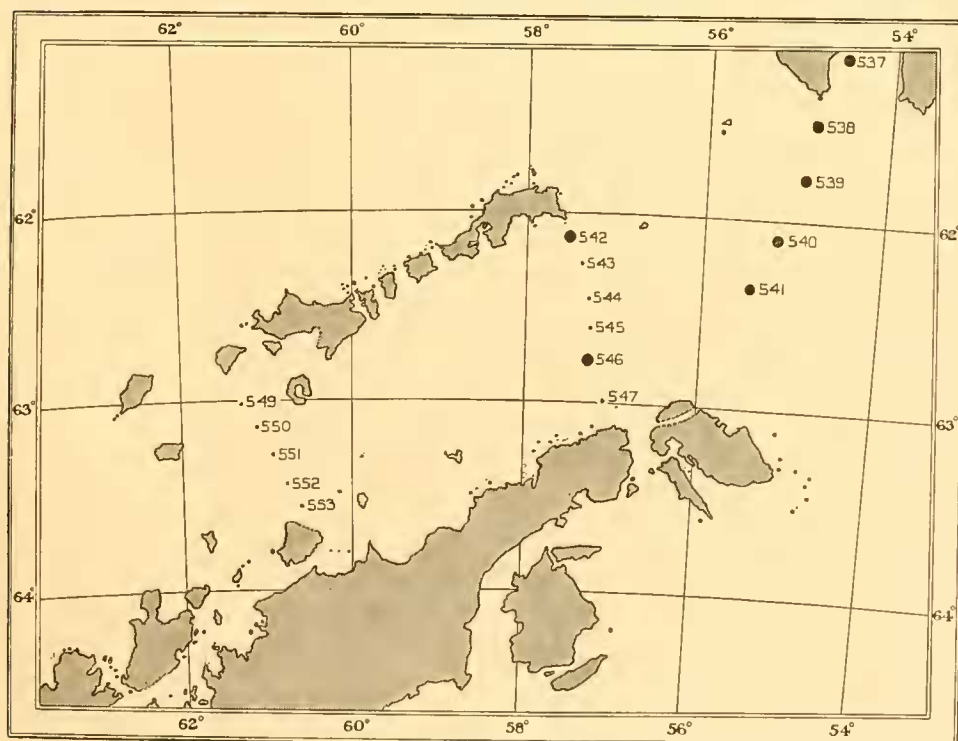


Fig. 53. Distribution of young *Euphausia superba*, Bransfield Strait survey (70-cm. net hauls), December 1930.

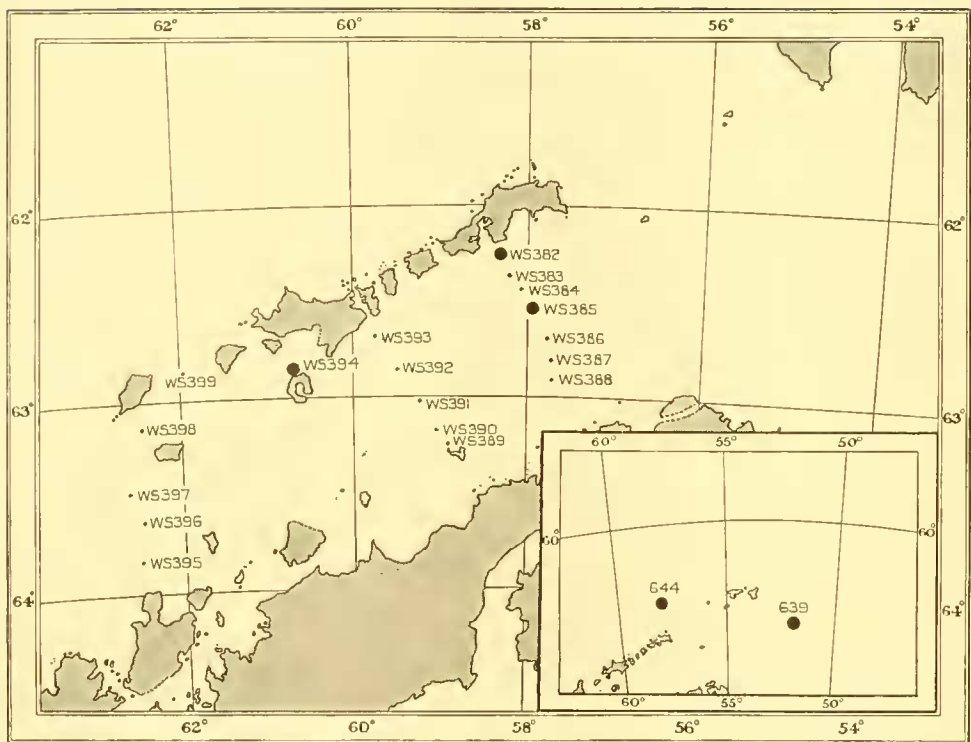


Fig. 54. Distribution of young *Euphausia superba*, Bransfield Strait survey (70-cm. net hauls), February 1929, and inset March 1931.

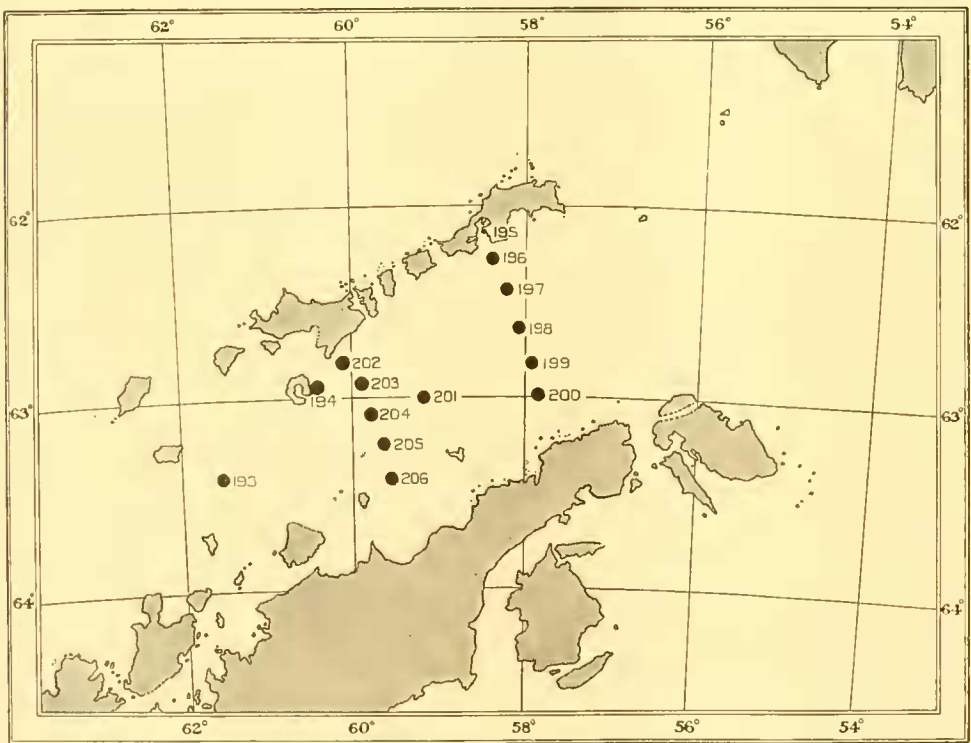


Fig. 55. Distribution of young *Euphausia superba*, Bransfield Strait survey (70-cm. net hauls), March–April 1927.

At St. 201, between the east and west lines, there were seven larvae with Furcilia 2 and 3 exceeding in number Furcilia 4.

Larvae were taken at each of Sts. 202–206: sixteen with Calyptopis 3 predominating, at St. 202; seventeen, with Furcilia 3 predominating but no Calyptopis present, at St. 203; twenty-nine at St. 204 with Furcilia 3 again predominating and five at St. 205 with two each of Calyptopis 2 and 3, and one Furcilia 1; three larvae were found at St. 206, comprising two Calyptopis 2 and one Furcilia 3.

St. 209 in the middle of Deception Harbour yielded one Calyptopis 2.

(g) Survey of April 1930 (Sts. 376–377).

These yielded no *E. superba*.

The Bransfield Strait stations are noteworthy as the source of most of the records of eggs in the plankton examined. Their abundance at certain stations has been discussed in the section dealing with the distribution of eggs. Here it may be noted that in this area, so highly specialized as far as hydrographic conditions are concerned, there is, following the incidence of eggs early in the season, a widespread abundance of larvae in the March–April survey. In this last survey Calyptopis 3 predominates and Furcilia 3 is conspicuous, but there is no well-defined directional arrangement in the distribution of these stages.

(7) Palmer Archipelago and Bellingshausen Sea

	Stations	Year	Time of year
(a)	WS 495–517	1929–30	December–February
(b)	558–604	1930–31	December–January
(c)	178–192	1927	March

(a) December–February 1929–30 (Sts. WS 495–517). Fig. 56.

Twenty-one vertical stations were made west of Graham Land in the Bellingshausen Sea: at two only was there evidence of *E. superba*. St. WS 496 in 631 m. off Adelaide Island gave one adolescent and two eggs and two eggs were found at St. WS 505 south-east of Peter I Island.

(b) December–January 1930–1 (Sts. 558–604). Fig. 57.

Only nine vertical stations were made in the Bellingshausen Sea and only two eggs were found, at Sts. 558 and 585. The former station was off the Biscoe Islands and the latter on the line made off Adelaide Island.

(c) Palmer Archipelago in March 1927 (Sts. 178–192). Fig. 58.

Five vertical stations were made in the neighbourhood of Anvers and Brabant Islands, but only two Calyptopis were taken—at St. 187 in the Neumayr Channel.

The scarcity of plankton in the Bellingshausen Sea has been noted by Mackintosh (1934), and *E. superba* is no exception to the general rule. Most of the stations, however, were taken at a time of year when it would not be expected that many larvae would be found, and although the adolescents, as will be seen later, were also few in number I do not think that the evidence obtained here is sufficient to form any general conclusion about the occurrence of very young larvae in this region.

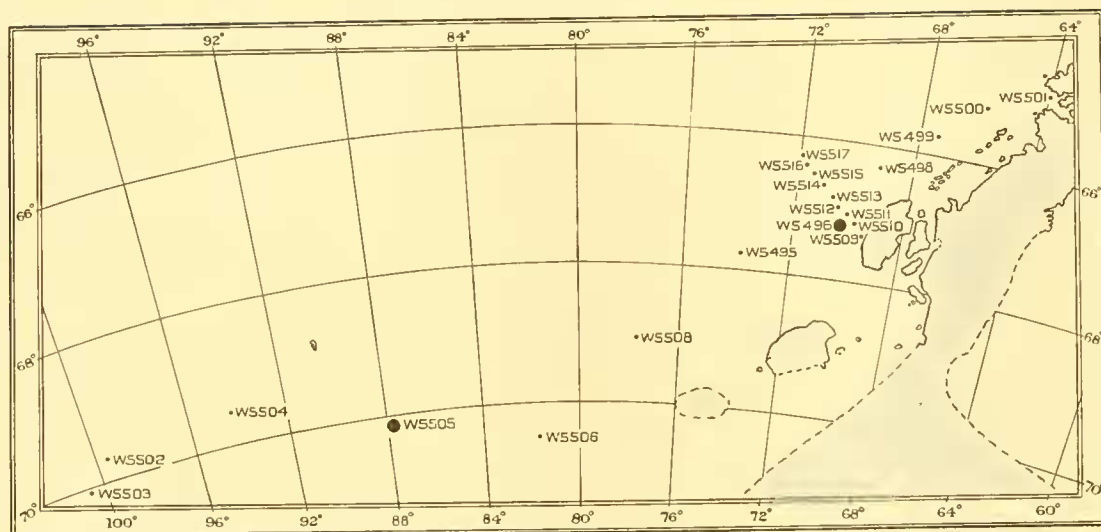


Fig. 56. Distribution of young *Euphausia superba*, Palmer Archipelago and Bellingshausen Sea (70-cm. net hauls), December–February 1929–30.

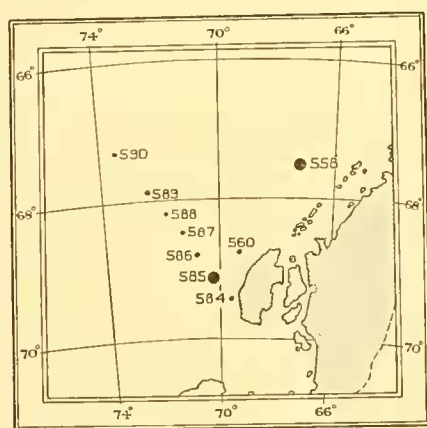


Fig. 57. Distribution of young *Euphausia superba*, Bellingshausen Sea (70-cm. net hauls), December–January 1930–1.

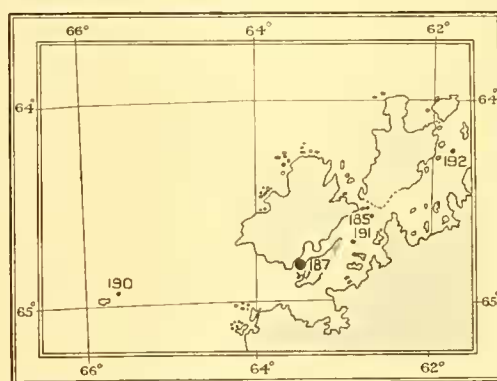


Fig. 58. Distribution of young *Euphausia superba*, Palmer Archipelago (70-cm. net hauls), March 1927.

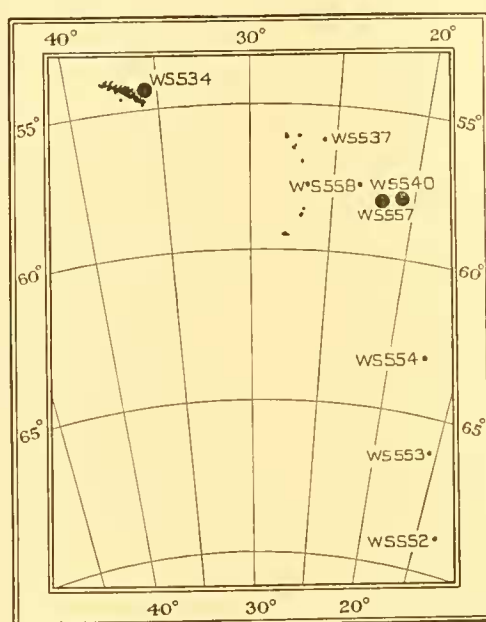


Fig. 59. Distribution of young *Euphausia superba*, Weddell Sea (70-cm. net hauls), January–February 1931.

(8) East of South Georgia

(a) Sts. WS 297-310, observations in pack-ice in October 1928.

(b) Sts. 452-471, Cape Town-Bouvet-South Georgia in October 1930.

(a) October 1928 (Sts. WS 297-310).

At eight vertical stations made in the vicinity of pack-ice only six larvae were taken, three being *Furcilia* 6, two adolescent and one undetermined. They were found at Sts. WS 297, WS 307 and WS 310. The 1-m. nets, however, give a better indication of the occurrence of these forms.

(b) Cape Town-Bouvet Island-South Georgia, October 1930 (Sts. 452-471).

St. 452 was the first south of the Antarctic convergence on the track between Cape Town and Bouvet Island. No larvae were taken there in the vertical nets, and at the following stations only *E. superba* of the previous year class were encountered. Here again the 1-m. nets give a much better idea of abundance. Larvae were obtained at Sts. 453 and 471 only. At the former station one adolescent was taken in the surface net, and at the latter there were thirty-three *Furcilia* 6 and thirty-three adolescents, again in the surface net.

This section is important, if only in a negative manner, so far as younger stages are concerned. The stations were all taken very early in the summer season and no eggs or first season larvae were obtained.

(9) The Weddell Sea, January-February 1931

(Sts. WS 534-561). Fig. 59

A line of stations was made in January-February 1931 from South Georgia *via* the Sandwich Islands into the Weddell Sea as far south as $68^{\circ} 53'$. There were twenty-eight stations at eight of which vertical nets were fished. On the outward journey at St. WS 534 and WS 540 respectively, east of South Georgia and the Sandwich Group, *Furcilia* 6 and adolescents were taken in moderate quantity. On the return journey, at St. WS 557, one damaged juvenile was taken. No larvae or eggs were found in the Weddell Sea proper, and the 1-m. nets bear out this scarcity. In these nets the juvenile *E. superba* taken are entirely restricted to the northern stations, and are all of the previous year class. The numbers of *E. superba* in the 70-cm. vertical nets are as follows: St. WS 534 ninety-six; St. WS 540 twenty-five; St. WS 557 one.

MATERIAL OBTAINED DURING THE CIRCUMPOLAR CRUISE

A general account of this cruise of the R.R.S. 'Discovery II' is given by John (1934). A series of voyages to and from the ice-edge on a course east-about from South Africa to South America was made during the winter months, and the importance of these, so far as the present investigation is concerned, is twofold. The observations were the first made in the winter months, and they were made in regions of the Antarctic from which we had not previously had plankton samples. John picked out the young *E. superba* and sent them to me, together with valuable notes of the environmental conditions in which the larvae were taken. I have also had access to the scientific reports sent by him to the Discovery Committee.

The observations are derived from the records of the 1-m. net hauls and not from the 70-cm. vertical net hauls. In a previous section attention was drawn to the selectivity of these nets, and it was pointed out that the larger nets give a better indication of the presence of larger larvae. At the time of year when the circumpolar cruise was made, larger, rather than smaller, larvae were to be found, so that the records obtained form a useful link both in time and developmental stages between those of the 70-cm. nets, concerned chiefly with larvae of the first year class, and those of the 1-m. nets examined with special reference to larvae of the second year class.

The following is a list of the sections into which the stations of the cruise have been subdivided (see Fig. 60):

- (a) Cape Town–Enderby Land–Fremantle, April 1932.
- (b) Fremantle–Adélie Land–Melbourne, May 1932.
- (c) Melbourne–ice-edge–New Zealand, June 1932.
- (d) New Zealand–ice-edge–subtropical convergence, September 1932.
- (e) Bellingshausen Sea, October–November 1932.
- (f) South Georgia–ice-edge–Cape Town, March 1933.

In the section (e) incidental reference is made to catches of young krill from the vicinity of South Georgia and from the Weddell Sea, with which the krill from the Bellingshausen Sea is compared.

- (a) Cape Town–Enderby Land–Fremantle, April 1932 (Sts. 843–876).

The first cruise began at Simonstown on April 8, and at St. 852, four stations north from the turning point at the ice-edge, krill was taken. Larvae were found in increasing amount until the ice-edge was reached.

One *Furcilia* 2 was found at St. 852. At St. 853 six larvae representing *Calyptopsis* 3, *Furcilia* 1 and 2 were taken, with the *Calyptopsis* predominating. Nineteen larvae were taken at St. 854, with *Calyptopsis* 3 predominating and *Calyptopsis* 2 and *Furcilia* 1 present. At St. 855 close to Enderby Land, there were 575 larvae in the surface net with *Calyptopsis* 3 predominating and *Calyptopsis* 2 and *Furcilia* 1, 2 and 3 represented. In the lower net there were four *Calyptopsis* 2 and six *Calyptopsis* 3.

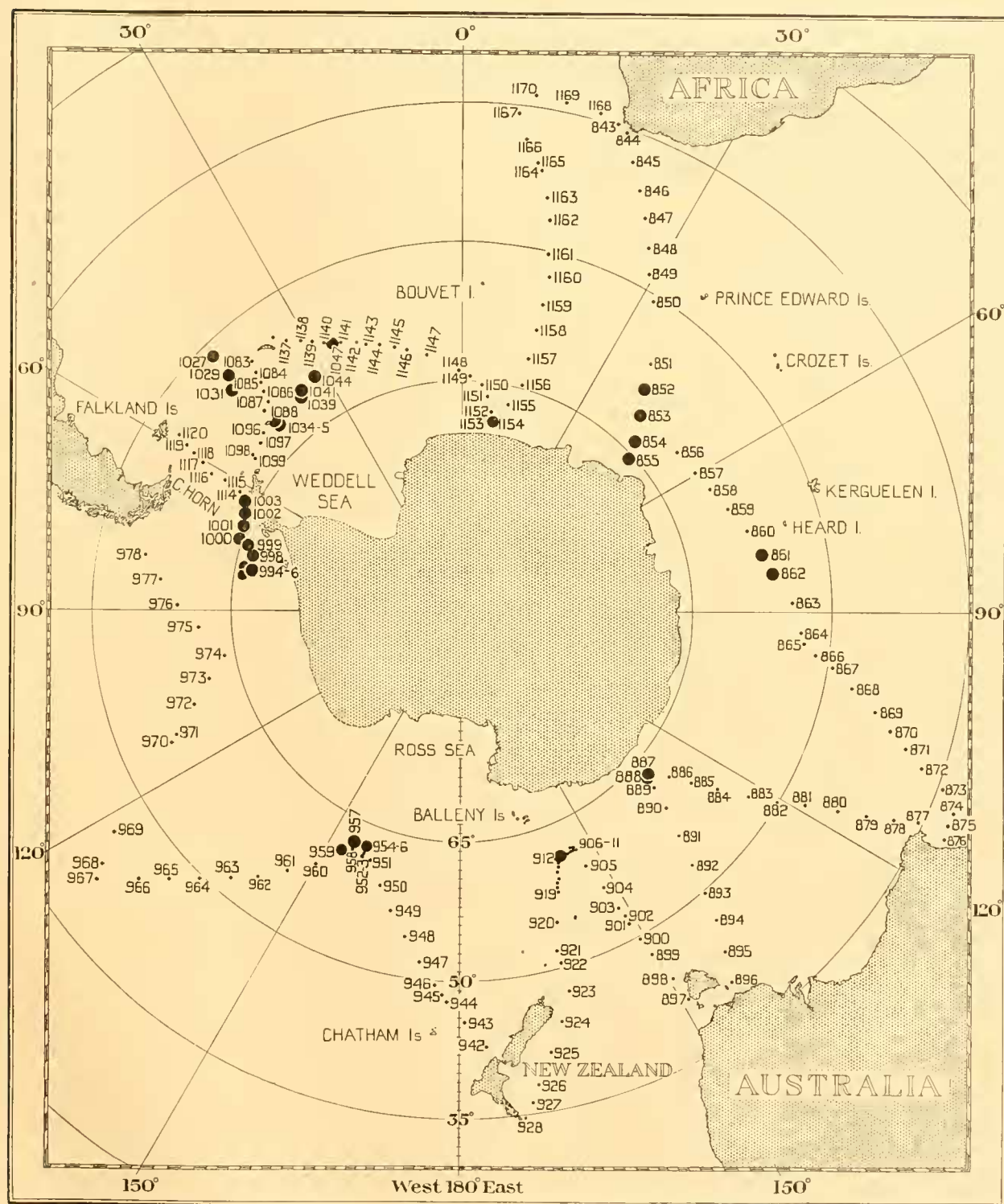
No larvae were taken again until St. 861, where deep and shallow nets were towed. In the shallow net were 131 larvae, and in the deep 86. No *Calyptopsis* were taken but *Furcilia* 1–5 were present with *Furcilia* 2 predominating. At St. 862 most of the larvae (39) were again concentrated in the upper net; in the lower net there were five. *Furcilia* 1–6 were present with *Furcilia* 4 the most abundant.

John suggests that the presence of larvae at Sts. 861 and 862 was due to the stations having been made where the surface layer was of cold Antarctic water deflected northwards along the west side of the Kerguelen-Gaussberg ridge.

The majority of the larvae, taken in April off Enderby Land, were *Calyptopsis* with a rise to dominance of *Furcilia* 2 and 4 at Sts. 861 and 862.

- (b) Fremantle–Adélie Land–Melbourne, May 1932 (Sts. 877–896).

On the second visit to the pack-ice only small numbers of larvae were obtained. John states that they met young pancake-ice in $63^{\circ} 41\frac{1}{2}'$ S as darkness fell. A station (887) was made and larval krill was taken. John had hoped that on the following day they would find the pancake-ice had formed a narrow fringe along pack-ice near which he anticipated finding large numbers of krill larvae: but during the night pancake-ice began to form around the ship, so she turned and steamed northwards making St. 888, twenty-five miles from the edge of the ice.



At St. 887 in the pancake-ice seventy-two larvae were taken in four different net hauls. No stage earlier than *Furcilia* 2 was recorded, which was the most abundant form; *Furcilia* 3, 4 and 5 were also present. Only one of the larvae was taken in deep water, the remainder being caught in horizontal nets towed at the surface or oblique nets fishing about 100 m.

At St. 888 there were twenty-six larvae comprising *Furcilia* 2 and 3, with the former predominating.

The small number of larvae obtained on this second visit to the ice-edge led John to believe that large numbers of larvae were to be expected, not in the young newly formed pancake-ice, but along the edges of the older pack-ice. This influenced the observations made on the third visit to the ice-edge between Melbourne and New Zealand in late June.

(c) Melbourne-ice-edge-New Zealand, June 1932 (Sts. 897-928).

In June, on the third journey southward, the ice-edge was encountered in 61° S, farther north than on either of the two previous occasions. The ship met light pancake-ice on the night of June 22 and steamed through it in search of pack-ice, but none was found, and the pancakes became too tightly packed to make a full station in darkness possible. The ship therefore steamed to the edge of the ice and made a full station, no krill or krill larvae being obtained. In the morning the 'Discovery II' again steamed into the pancake-ice but could see no sign of pack-ice to the south so she turned east and steamed through the pancake-ice, making three oblique towing stations at four-hourly intervals. No krill was taken at any of these stations nor at a station made at night at the edge of the ice. Throughout the night the ship steamed eastward parallel to the edge of the ice and entered it to continue the search the following morning. Oblique nets were towed and small numbers of late *Furcilia* were taken in the upper nets.

The 1-m. and 70-cm. nets were fished on the same warp just below the surface and clear of the ice; they were closed before hauling in. The 1-m. net was at a depth of 2 m. and caught large numbers of larvae; the 70-cm. net at 5-7 m. caught none. The nets were fished again in the same way with the same results. A full station was subsequently made in the ice but no young *E. superba* were taken in the vertical net hauls. They were caught again in large numbers in the 1-m. net, and on this occasion in the 70-cm. net, towed just below the ice at the end of the station.

Krill had been taken on the previous cruises some distance from the ice in the cold westward-flowing Antarctic water, but after leaving the ice on this last occasion, although oblique nets and a horizontal surface 1-m. net were towed every four hours until the boundary of the cold water was reached, neither adult nor larval krill was taken.

The sample of krill analysed, from the 1-m. horizontal net towed at 2 m. at St. 912, consisted of one-eighth of the total number, 1616. *Furcilia* 4, 5 and 6 and one adolescent were taken, with *Furcilia* 6 greatly predominating over the other stages found.

John states that the horizontal *surface* hauls near the ice were enormous compared with the oblique hauls.

(d) New Zealand-ice-edge-subtropical convergence south of mid-Pacific, September 1932 (Sts. 942-967).

The search for young *E. superba* along the ice-edge on this cruise resembled that made on the previous visit, but the number taken was much smaller. Two days were occupied in the search, and the night between was spent steaming eastwards along the ice-edge. Twenty-one net hauls were made in the ice and along its edge; eight of them were the routine oblique hauls from 250-100 m. or from 100 m. to the surface and thirteen were horizontal surface hauls made particularly for the purpose of catching young krill. The total number taken was small, approximately 220; only one adult was obtained.

At St. 954, 0-5 m., 108 *Furcilia* 6 and adolescents were taken, with the latter predominating. It was observed that, contrary to the usual length distribution of young *E. superba*, in this instance they fell into two well-defined length groups, the lower with an average about 13 mm. and the higher about

17.5–18 mm. These two maxima were not connected with the stage of development, for in the lower group Furcilia 6 and adolescents were present in approximately equal numbers, while in the upper the larvae were entirely adolescent. It cannot be, therefore, that the second length group is the result of the larvae moulting, with sudden increase of length from Furcilia 6 to adolescent. The first length group thus does not moult directly to the second.

At St. 959 there was a similar distribution of length groups, but not quite so well-defined. The larger group is still too small to be regarded as the young adults of the ensuing season. Our figures for the average length of adolescents show that normally they reach about 20 mm. by the end of the first half of their second summer season, so that they would be much larger nine months later. It is more likely that at each of Sts. 954 and 959 we are dealing with two different broods belonging to the same year class. It may be that the larger group originates from eggs spawned very early in the previous season or, as suggested by John in his report, concerning a similar length distribution of larvae late in the circumpolar cruise, the size difference may be due to better conditions for growth in certain areas, such as a more abundant diatom flora.

At St. 955 young *E. superba* representing Furcilia 6 and adolescents were taken, with the latter predominating. At St. 956 only two Furcilia 6 were taken and at St. 957 three undetermined stages. One adult and eighty young were taken at St. 959, with adolescents predominating.

(e) Bellingshausen Sea, October–November 1932 (Sts. 968–1003).

The second portion of the W-shaped track from New Zealand to Magellanes was made in conditions which prevented the ship from reaching the ice-edge. Fuel was short and a prolonged gale interfered with the programme arranged. The ship turned northwards again in $63^{\circ} 57' S$, $101^{\circ} 16' W$ with clear water to the southward. No krill was taken.

From Magellanes another V-shaped cruise was made at the end of October and beginning of November, south to the edge of the pack-ice and then north-east roughly parallel to the Graham Land Coast.

Young krill, but no adults, occurred in very small numbers in nine of the ten stations made along and near the pack-ice—the total number from both the oblique 1-m. and 70-cm. nets and the horizontal surface nets was only 170 individuals, 113 of which were taken at the northernmost station (1003). Furcilia 6 predominated, whereas south-east of New Zealand in September adolescents and Furcilia 6 were in about equal numbers if the second larger length group is ignored; adolescents greatly preponderated if the larger group is included.

The Bellingshausen Sea krill were measured by John, and later the small numbers taken at Sts. 1027 and 1031, and 200 young from a large haul of mixed old and young krill from St. 1029, were measured. These stations were to the north-west, south-west and west of South Georgia, far from the ice. A third batch of young krill, taken from six stations near to the Weddell Sea ice (Sts. 1034, 1035, 1039, 1041, 1044, 1047) was measured by John.

The length-frequency distribution of these three samples of krill is shown in the graphs in Fig. 61.

The young krill from the Bellingshausen Sea (*A*) were taken between October 29 and November 2; they were small. An analysis of the young krill taken south-east of New Zealand seven weeks earlier showed it to be composed of two size groups falling about the lengths of 12 and 20 mm. The majority of the Bellingshausen Sea krill were 12–14 mm. long and would have been a millimetre or two less in early September.

The young euphausians from the open sea to the west of South Georgia (*B*) and those from the Weddell Sea ice-edge (*C*), all of which fall about the lengths of 24–25 mm., were taken between November 18 and 30, that is two to four weeks later than those from the Bellingshausen Sea. The period between the observations is not sufficient to account for the great difference in size. The similarity of the two populations represented by the curves (*B*) and (*C*), together with Deacon's discovery of the existence of a constant flow of water from the Weddell Sea towards the Shag Rocks, makes it certain that the krill in the open water to the west of South Georgia was of Weddell Sea origin. It is suggested by John that better conditions for growth in the ice-free water, such as the

more abundant diatom flora, may account for their larger size compared with those taken immediately afterwards along the ice-edge.

The graph *C*, representing the Weddell Sea ice-edge yearling krill, is the only one of the three graphs having two peaks showing two widely separated size groups in the population; but, as John remarks, more knowledge is necessary to understand what it and the two smaller and less widely separated size groups in the Bellingshausen Sea yearling krill mean.

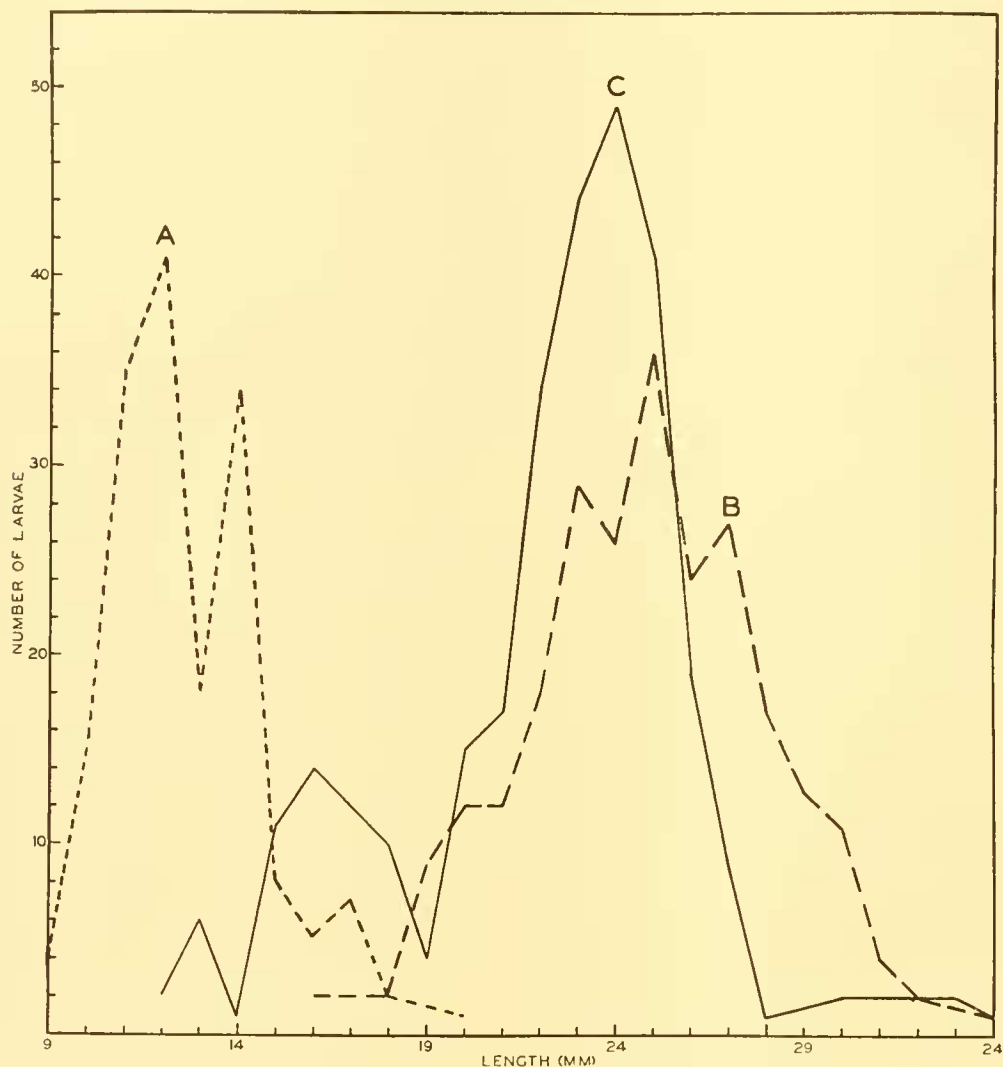


Fig. 61. Analyses of length frequencies of samples of young *Euphausia superba*:
A, Bellingshausen Sea; B, South Georgia; C, Weddell Sea ice-edge.

(f) South Georgia-ice-edge-Cape Town, March 1933 (Sts. 1137-1167).

The last of the V-shaped sections of the circumpolar cruise from South Georgia to the ice-edge far to the east and south, and from there to Cape Town was made in March 1933.

I have not had the opportunity to examine the krill taken during this voyage but quote from John's report: "Although the places where we made many of our stations and the times at which we made them were places and times at which larval krill might have been expected we did not recognize any in our hauls. . . . Catches of large numbers of adult krill have been few although we continued to tow a surface metre net in addition to the oblique series at every station. We saw no krill patches. Near the ice-edge, in 69° S, 9° E, we followed our usual practice on such visits of towing net after net, until

we obtained a quantity of krill. They were adolescents of an unexpectedly small size, the majority being a little smaller than those taken along the Weddell Sea ice-edge three months before."

The observations made during the circumpolar cruise are of great help towards a better understanding of the development and distribution of *E. superba*. The dominance of successive stages is made clear; in April Calyptopis 3 and early Furcilia stages are most abundant, in May Calyptopis stages have disappeared and Furcilia 2 predominates, in June it is Furcilia 6 and in September adolescent forms which have the chief place.

The concentration of the larvae at the ice-edge with the coming of winter is demonstrated. In April it is found that larvae occur both at the ice-edge and at a distance from it (Sts. 852-855), but in May, June and September they are concentrated exclusively at the ice-edge. It has been suggested above that at Sts. 861 and 862 the presence of larvae away from the ice-edge is connected with the deflection northwards of Antarctic surface water along the west side of the Kerguelen-Gaussberg ridge. In support of the suggestion that the larvae have been carried northwards in the surface water is the occurrence of typical ice-frequenting plankton at Sts. 861 and 862, and the absence of such plankton and young krill at five preceding stations, all of which, like Sts. 861 and 862, were made in the hours of darkness.

Movement southwards of the krill is ultimately limited by the ice-edge (see p. 159), and accumulation of larvae in that region is brought about by this limitation and augmented by the expansion of the area of ice-covered water with the coming of winter. At stations made in May, June and September no krill was found except at the ice-edge: its absence elsewhere can be explained if advance in time of year is brought into account. The southward movement of larvae developed in more northerly regions will have been terminated by the ice-edge being reached, and accumulation there will have been speeded up by the northward spreading of the ice field with the advent of winter conditions. In the Falkland sector it was found that in the summer larval krill was diffuse in its distribution, and there is no apparent reason against assuming a similar distribution in other parts of the Antarctic. On the other hand, the observations made during the circumpolar cruise give clear evidence of concentration in the vicinity of the ice-edge in winter. It is likely that the changes of distribution are brought about by the factors mentioned above.

MATERIAL CAUGHT IN THE 1-M. NETS

For information about the occurrence of larvae in their second season the data supplied by the oblique hauls of the 1-m. nets will be considered. The material is derived from stations made by R.R.S. 'William Scoresby' during the seasons 1928-9, 1929-30 and 1930-1; and by R.R.S. 'Discovery II' during the season 1930-1. The time of year covered is from August to February, but the number of observations for the latter month and January is very small.

It will be found convenient to take the stations in their chronological order, starting with the William Scoresby stations in August 1928.

Falkland Islands to South Georgia, August 1928 (Sts. WS 251–256). Fig. 62.

The Antarctic convergence was crossed between Sts. WS 253 and WS 254, and at the latter the first station to the southward of it a small quantity of young krill was taken. At the succeeding stations towards South Georgia krill was also present in small quantities. The stations which were made in late winter were nevertheless in ice-free water, no pack was encountered.

South Georgia survey, August–November 1928 (Sts. WS 257–285, WS 289–296, WS 311–313). Fig. 63.

The observations off South Georgia in the early part of the 1928–9 season were divided into three by two visits to the pack-ice to the east of South Georgia.

In the first set of observations, Sts. WS 257–285, four lines from Bird Island, Prince Olaf Harbour, Cape Larsen and Cape Vakop were made, between August 28 and September 18.

At every station, with the exception of two on the Bird Island line, young krill was taken in comparatively small numbers for the most part, but with indication of a rather greater concentration eastward of South Georgia at the outer stations of the Larsen and Vakop lines. On the last station on the Vakop line (St. WS 285), the largest catch of 1600 individuals was made.

From St. WS 285 the 'William Scoresby' steamed south to the edge of the not far distant pack-ice where, as will be seen in the next section, abundant krill was found.

The line from Cooper Island was completed at the beginning of October, and at each of the stations from WS 291 to 296 krill was taken. At the inner stations the quantity was small, whilst the two outer stations yielded moderately abundant amounts.

The three stations WS 311–313 to the eastward of South Georgia were made between October 10 and November 5, only one young euphausian being taken.

The pack-ice stations, September–October 1928 (Sts. WS 286–288, WS 297–310). Fig. 64.

On September 18, on the way from the outermost station on the Vakop line to the edge of the pack, St. WS 286 was worked, 900 young *E. superba* being taken. St. WS 287 was made inside light pack-ice a few miles from the edge; only a moderate number of krill was taken. St. WS 288, worked just outside the edge of the pack-ice, yielded over 20,000 young *E. superba* from one net haul. It is interesting to note that this last station was made during the day at 1410 hours and that the net was fished from 102 to 0 m., showing that in certain circumstances, if not invariably, the young *E. superba* do not obey the same rhythmic diurnal migration noted in earlier larval forms, but may remain at the surface during the hours of daylight.

On the second visit to the ice east of South Georgia, nearly all the stations (WS 297–310) were worked in the neighbourhood of the ice, and at every station, whether actually in close proximity to the pack or so far from it that no note of its presence has been recorded in the station list, krill was found. It should be noted that at such stations as WS 304 and WS 305, where the pack-ice was at some distance, there were as many young euphausians taken as at stations worked at the edge of or actually in pack-ice. When it is realized that the pack-ice is capable of considerable and rapid local movement, due to wind, one would not anticipate that the greatest concentration of the animals would necessarily be in the immediate proximity of the pack-ice, but rather that they should be distributed within the area of the ice-edge movement.

Falkland Islands to South Shetland, November 1929 (Sts. WS 468–474). Fig. 65.

The next line of stations is that made in November of the following year between Falkland Islands and South Shetland. At St. WS 468 made close to the Antarctic convergence one *Furcilia* 6 was taken, and at St. WS 474, west of Elephant Island, two *Furcilia* 6 and one adolescent. No krill was taken at the intervening stations.

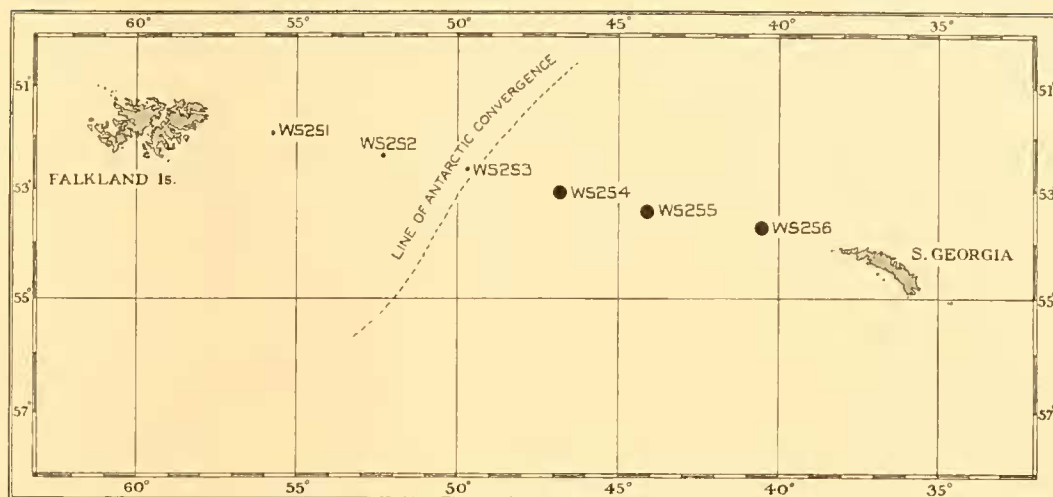


Fig. 62. Distribution of young *Euphausia superba*, Falkland Islands–South Georgia (1-m. net hauls), August 1928.

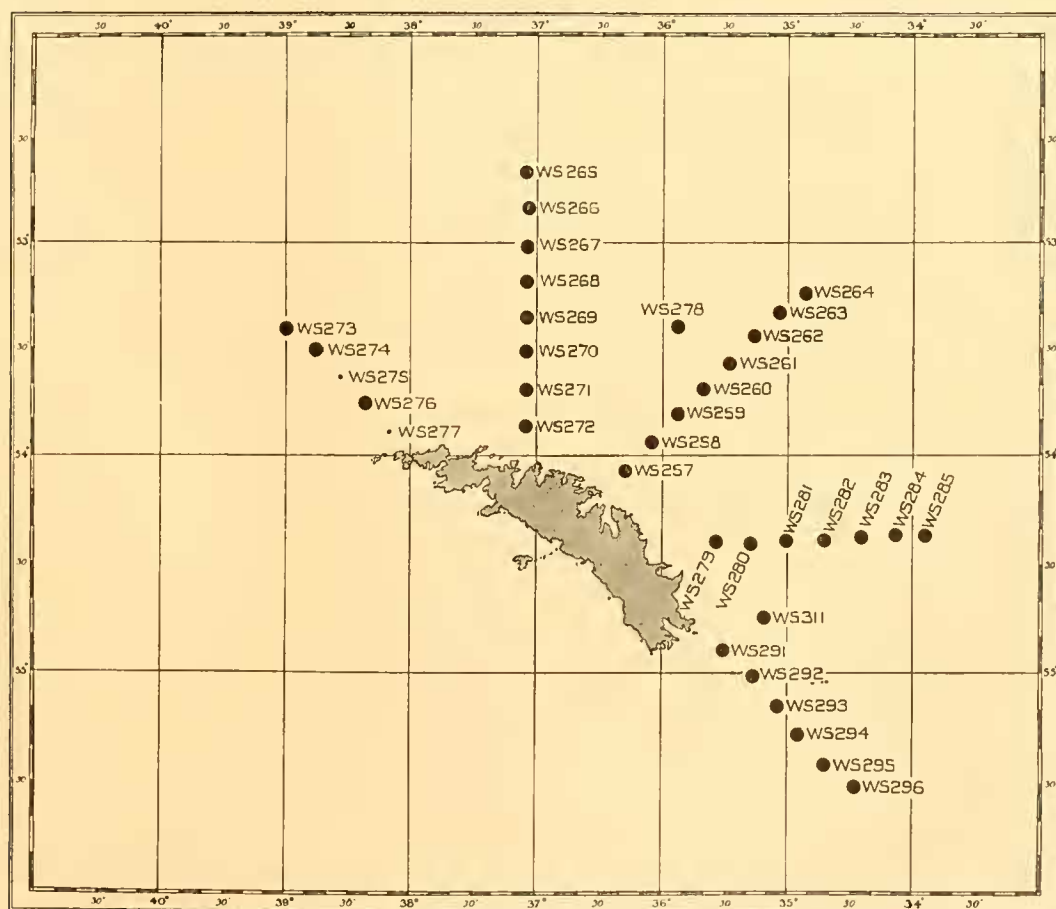


Fig. 63. Distribution of young *Euphausia superba*, South Georgia survey (1-m. net hauls), August–November 1928.

Bransfield Strait survey, November 1929 (Sts. WS 475-494). Fig. 66.

In the November 1929 survey of the Bransfield Strait young *E. superba* were only abundant at one station (WS 487) at the southern end of the middle line. 1424 were taken, whereas at the remaining stations comparatively small numbers were recorded. The krill was distributed throughout the area of the strait, with an indication of greatest concentration on the Graham Land side.

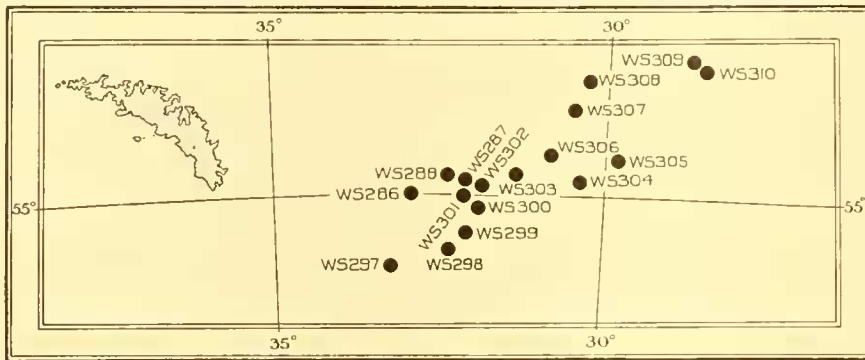


Fig. 64. Distribution of young *Euphausia superba*, pack-ice stations (1-m. net hauls), September-October 1928.

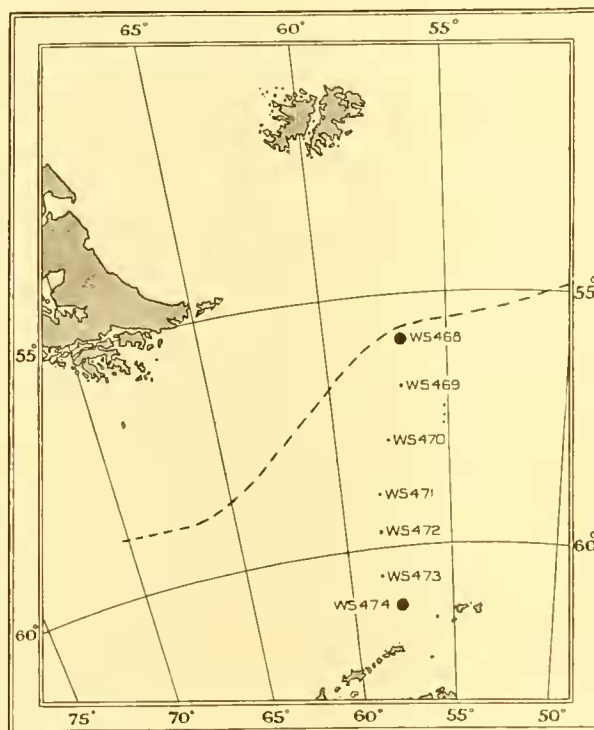


Fig. 65. Distribution of young *Euphausia superba*, Falkland Islands to South Shetlands (1-m. net hauls), November 1929.

Bellingshausen Sea, December 1929-February 1930 (Sts. WS 496-517). Fig. 67.

The area covered by the stations in this section extends from Anvers Island westwards of Peter I Island to 100° W. The small quantity of krill taken is noteworthy. With the exception of a single individual at St. WS 508, north-west of Charcot Land, no krill was found to the west of Adelaide Island. The stations at which it was present, with the exception just mentioned, were all situated off

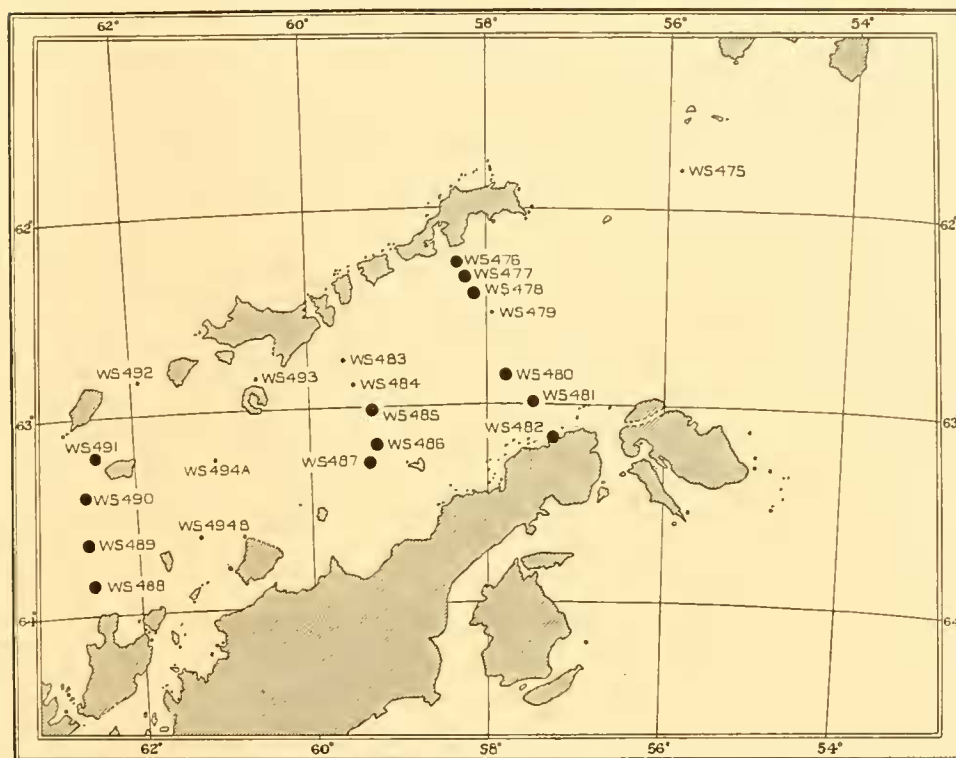


Fig. 66. Distribution of young *Euphausia superba*, Bransfield Strait survey (1-m. net hauls), November 1929.

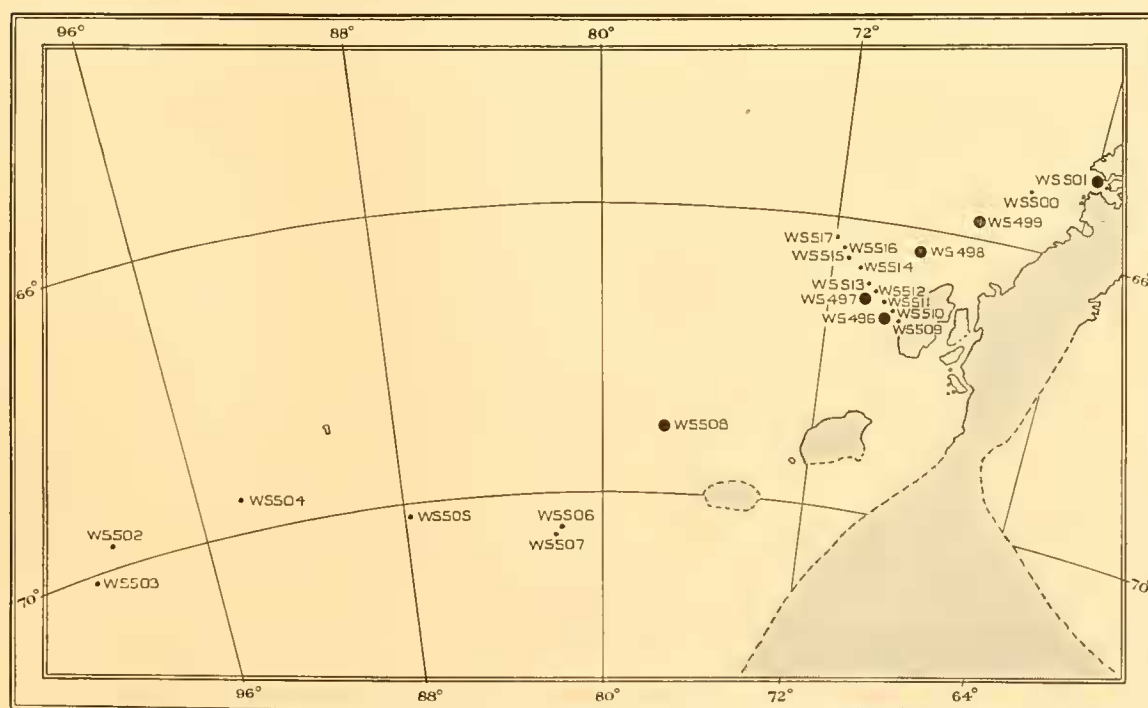


Fig. 67. Distribution of young *Euphausia superba*, Bellingshausen Sea (1-m. net hauls), December–February 1929–30.

the coast between Adelaide Island and Anvers Island, with greatest concentration off the former island. No krill was taken on the line of stations made to the north-west from Adelaide Island (Sts. WS 508-517).

Weddell Sea, January-February 1931 (Sts. WS 534-561). Fig. 68.

Towards the end of January 1931 the 'William Scoresby' sailed south-eastward from South Georgia, encountering pack-ice north of the South Sandwich Group. The ice was skirted to the eastward and was found to fall away to the south and east. The ship went southwards for about 600 miles in open water to $68^{\circ} 53' S$, $13^{\circ} 03' W$, where the pack was again encountered.

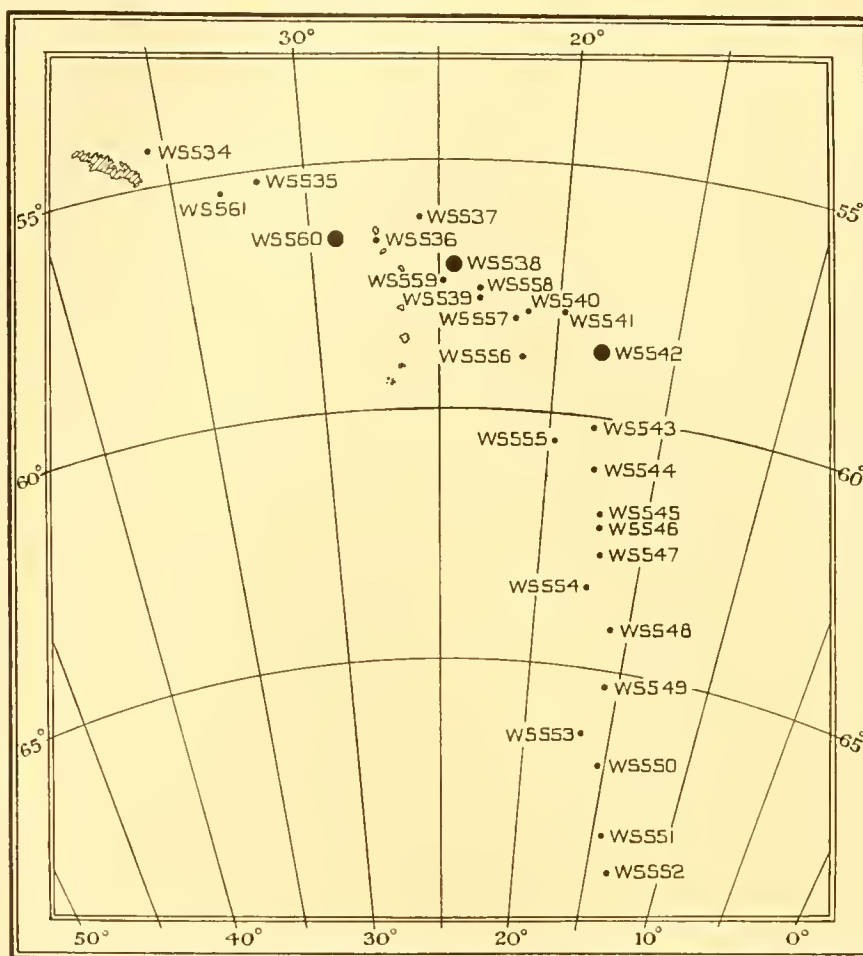


Fig. 68. Distribution of young *Euphausia superba*, Weddell Sea (1-m. net hauls), January-February 1931.

The stations where krill was taken are all concentrated on the northern part of the line between South Georgia and the point east of the Sandwich Group, where the ship turned southward into the ice-free water of the eastern Weddell Sea.

At St. WS 534 ninety-six young *E. superba* were taken in the vertical nets. At Sts. WS 538 and WS 542 they were abundant in the 1-m. nets, over 5000 individuals being taken at each of these stations, and the vertical nets at St. WS 540 contained a moderate number. *E. superba* was absent from all the stations southward from WS 539, including the ice-edge station WS 552, at which six sets of observations were made over a period of twenty-four hours. Flights of five closing metre nets were fished, the lowest at about 500 m.; in none of these was young *E. superba* taken.

Returning northwards again it was not until the ship reached the region in which krill had previously been found that one individual, at St. WS 557, was again recorded in the vertical net series. A small quantity of krill was taken at St. WS 560 in the 1-m. net, to the westward of the north end of the South Sandwich Group.

Cape Town–Bouvet–South Georgia, October–November, 1930 (Sts. 446–472). Fig. 69.

In October 1930 the 'Discovery II' sailed southwards on a line of stations from Cape Town to Bouvet and South Georgia. The Antarctic convergence was crossed between Sts. 451 and 452. The first catch of young krill was made at St. 453 where a large quantity was recorded. At Sts. 453–455, all in the neighbourhood of Bouvet, a considerable quantity of krill was taken, at the last station over 6000. From Bouvet Island to South Georgia the track was along the edge or through the outskirts of the pack-ice. Young *E. superba* were taken at each of the stations where the metre net was fished. At St. 461 a twenty-four hours station was made, the results of which are dealt with in a separate section. At St. 468 no 100-cm. nets were fished. In his report on this series of stations Dr Kemp, referring to *E. superba*, states: "We found krill first of all to the N.E. of Bouvet where we took a quantity of adults and a great number of late larval and early post-larval forms, stages that we had scarcely seen hitherto. Along the pack adults were again taken at many points and at every station

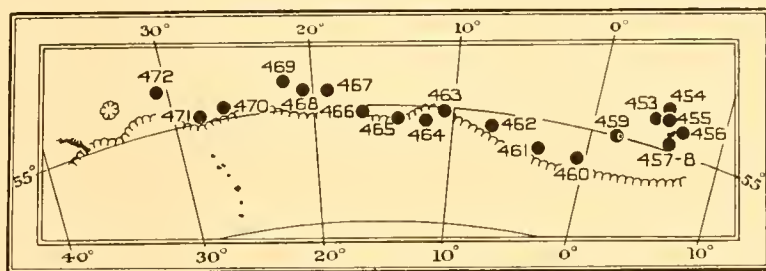


Fig. 69. Distribution of young *Euphausia superba*, Cape Town, Bouvet, South Georgia (1-m. net hauls), October–November 1930.

young have been obtained, usually in great abundance. When making our way through the pack, either in the main body of it or when crossing the narrow tongues, krill was almost always to be seen and often it occurred in great quantity. The young stranded themselves in numbers on floes that we momentarily submerged in our passage, while the adults, with greater activity, often jumped clear of the water and landed kicking on ice some 10 or 12 inches above the surface. The quantity of krill to be found in and near the pack at this season is amazing and the reason why whales haunt the ice-edge is evident."

South Georgia survey, November 1930 (Sts. 474–525). Fig. 70.

After the completion of the Bouvet–South Georgia stations a plankton survey round South Georgia was commenced. At the beginning of the survey, as stated by Mackintosh (1934, p. 127), the pack-ice was close up to the island, but at the end of November when the survey was completed the ice had receded some way to the south-east. There can be no doubt that the abundance in which young krill was found in the vicinity of South Georgia during this survey was due to the proximity of the pack to the island, and it is likely that earlier in this season the ice-edge extended north and west to the positions shown on the map where krill was especially abundant. It is likely too that the surface currents (*vide* Deacon, 1933, p. 183, fig. 5) would tend to transport the krill northwards and eastwards in the tongue of water extending along the north-east coast of South Georgia.

South Shetland survey, December 1930 (Sts. 537–555). Fig. 71.

In this survey the distribution of the young krill was much the same as that of the eggs described on p. 109. The greatest concentration was at St. 537, the first on the Elephant–Joinville line; this

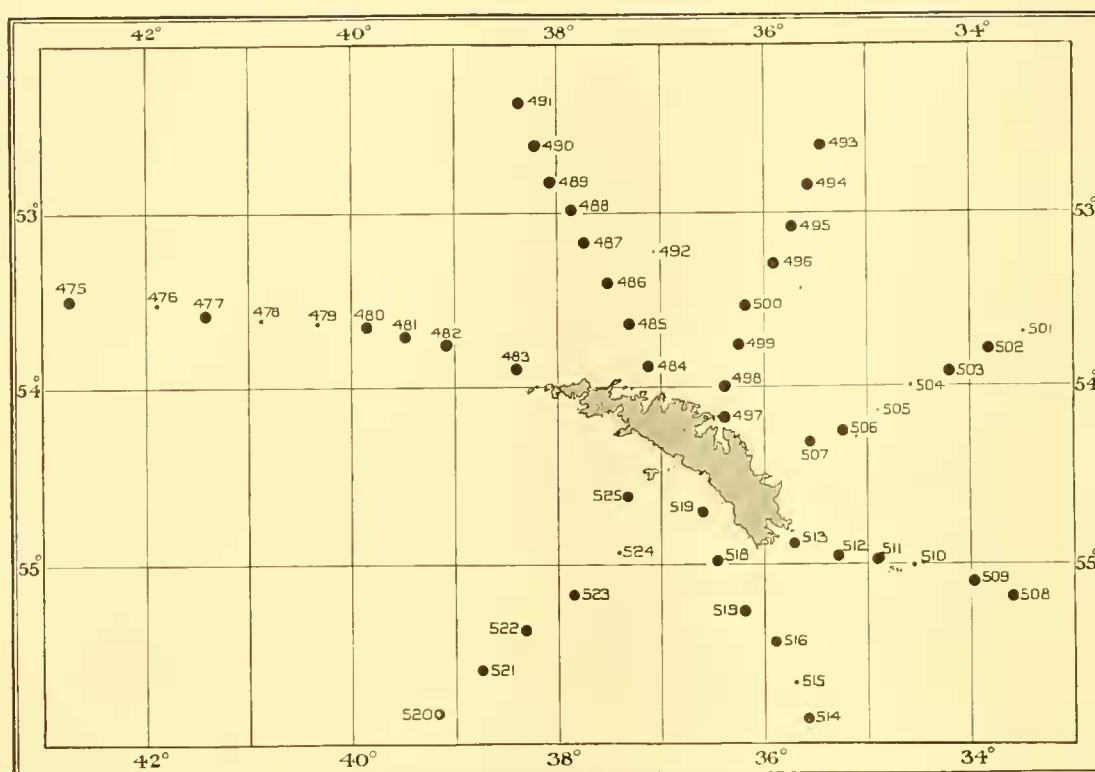


Fig. 70. Distribution of young *Euphausia superba*, South Georgia survey (1-m. net hauls), November 1930.

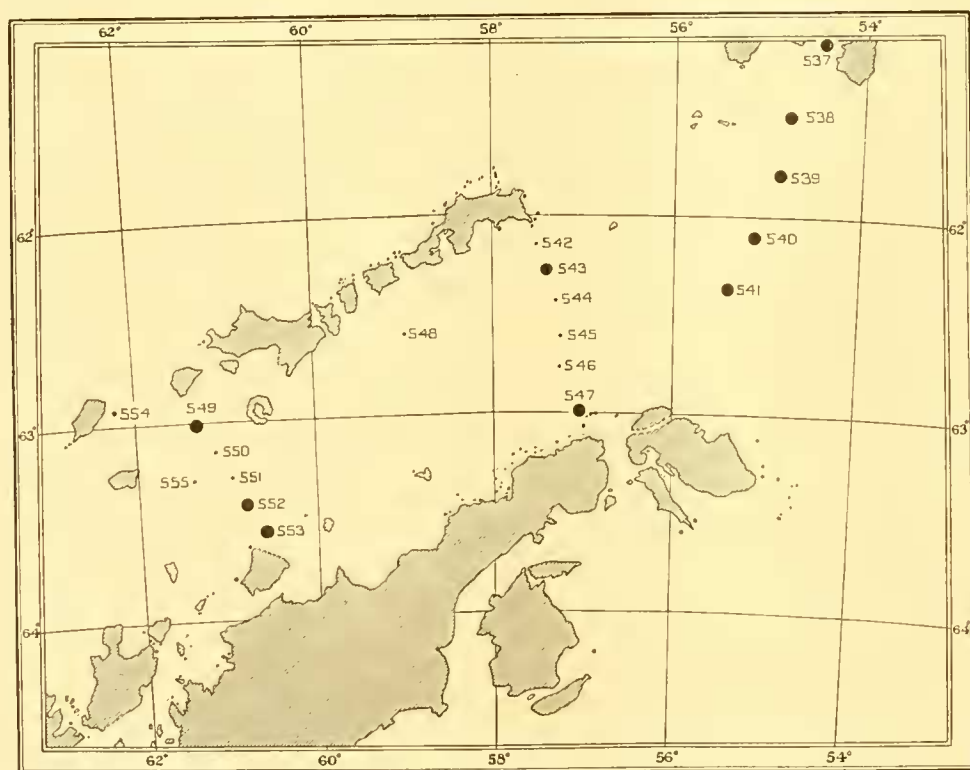


Fig. 71. Distribution of young *Euphausia superba*, South Shetland survey (1-m. net), December 1930.

station is situated between Elephant and Clarence Islands and over 7000 young *E. superba* were taken. Much smaller numbers were taken at Sts. 538–541, but some were present at each of the stations.¹ On the Cape Melville–Trinity Land line krill was in very small quantity at Sts. 543 and 547, two individuals being obtained at each, and was absent from the remaining stations. On the Snow Island–Trinity Island line there were ten at St. 549 and one each at Sts. 552 and 553, the southernmost stations in that line.

VERTICAL DISTRIBUTION

In this section the vertical distribution and migrations of *E. superba* from Calyptopis 1 to adolescent will be described. It was shown previously (p. 116) that, whereas the Metanauplius tends to remain in the same position whatever the time of day, there was evidence in the later larval stages of a pronounced diurnal migration. Before going on to deal with this in detail, it may be well to mention the difference in our results from those which Ruud obtained from his material (Ruud, 1932). He states in the summary of his paper (p. 93) that *E. superba* is a surface species, and that both the adults and the young in his catches were taken, almost without exception, above 200 m. "In other words", he remarks, "it belongs to the Antarctic surface layer." That this statement does not apply to all stages of the life history is made evident by the examination of the present material. The distribution of the adults is not within the scope of the present paper except to the extent that they are associated with the distribution of eggs, but there is some reason for believing that the adults seek the deeper water for the deposition of eggs. So far as larval stages from Calyptopis to adolescent are concerned we can demonstrate that they are not by any means restricted to the first 200 m.

The routine 70-cm. vertical net hauls made at plankton stations covered a range of 1000 m. from surface downwards or from surface to within a few metres of the sea-bottom if the depth were less than 1000 m. Six hauls were made with closing nets, as follows: 50–0, 100–50, 250–100, 500–250, 750–500 and 1000–750 m. The nets were hauled at a constant speed of 1 m. per second.

The depth through which the two uppermost nets were hauled is one-third that of the next lower net and one-fifth that of the three remaining nets. In order, therefore, to make the actual number of individuals in any one net haul comparable with the remainder, it is necessary to employ the lowest common multiple, which is 15, to obtain corrected totals. In the diagrams used to demonstrate vertical migration (Figs. 72 and 73) the width in each column represents the numbers in a 50-m. vertical haul between the indicated levels expressed as a percentage of the total. The day is divided up into six periods of four hours each, and each station has been placed in the four-hour period during which the greater part or the whole of the vertical net series was fished.

The larvae have been arranged in six groups of increasing development, the first three of which comprise the three Calyptopis stages; the fourth includes Furcilia 1, i.e. larvae with non-setose pleopods; the fifth includes Furcilia 2–4 and the intermediate forms with six and four terminal spines; the sixth group comprises Furcilia 5 and 6, including what were formerly recognized as Cyrtopia stages.

¹ For some reason not recorded these larvae were not measured. The numbers were: St. 538 twenty-three, St. 539 twenty-seven, St. 540 three and St. 541 nine.

Between six and seven thousand larvae have been examined in this analysis of vertical distribution. As might be anticipated, Calyptopis 1 is in greatest abundance, and the group made up by Furcilia 5 and 6 has the smallest number of individuals in it. It is

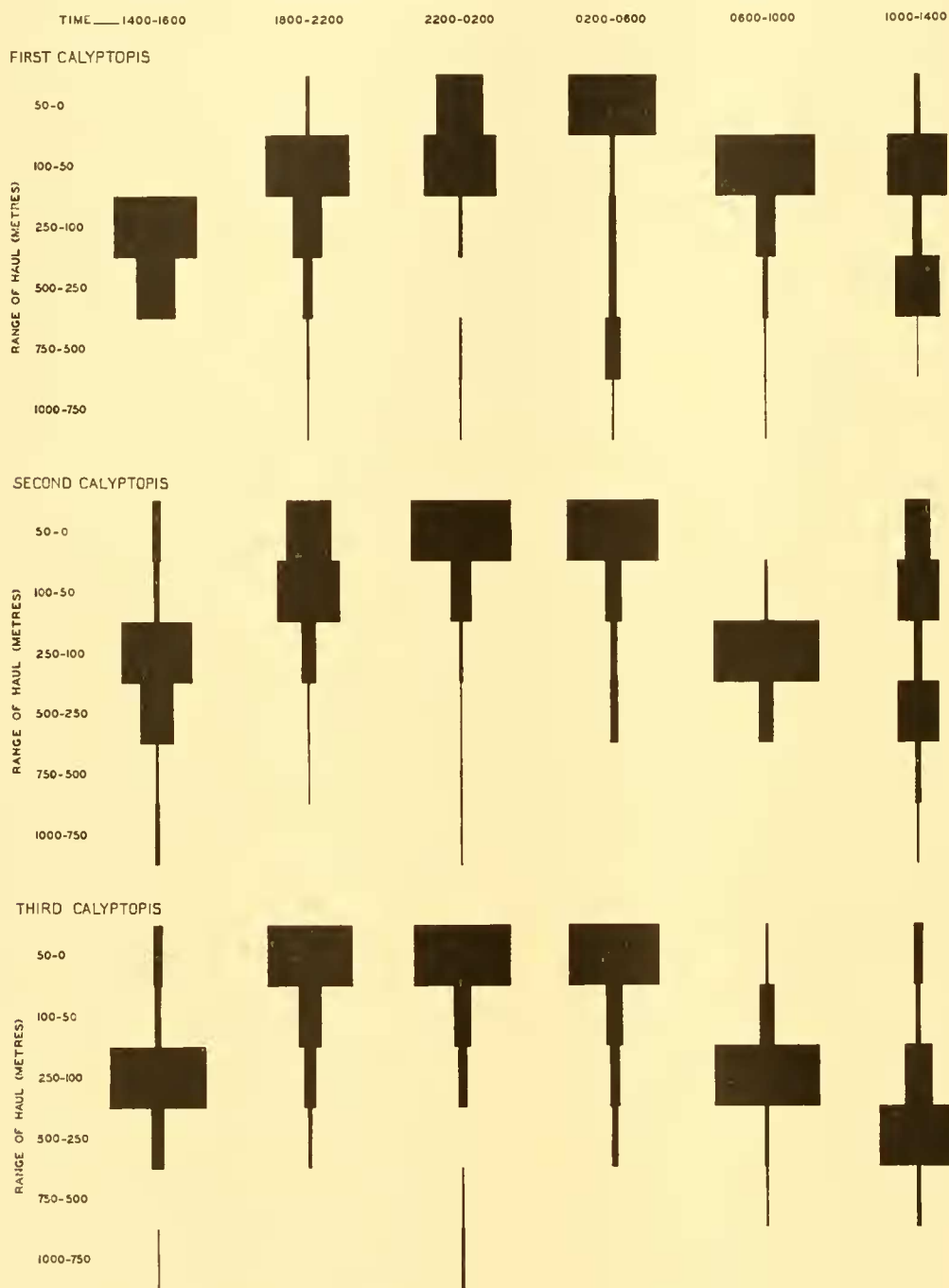


Fig. 72. Diagram showing diurnal vertical migration in Calyptopis 1-3 of *Euphausia superba*.

difficult to say how greatly the difference in number is due to the superior efficiency of the 70-cm. net in catching Calyptopis as compared with the larger larvae, and to what

extent the numbers taken may be an indication of the comparative abundance of the two forms.

The six diagrams show that, with the exception of Furcilia stages 5 and 6, larval forms

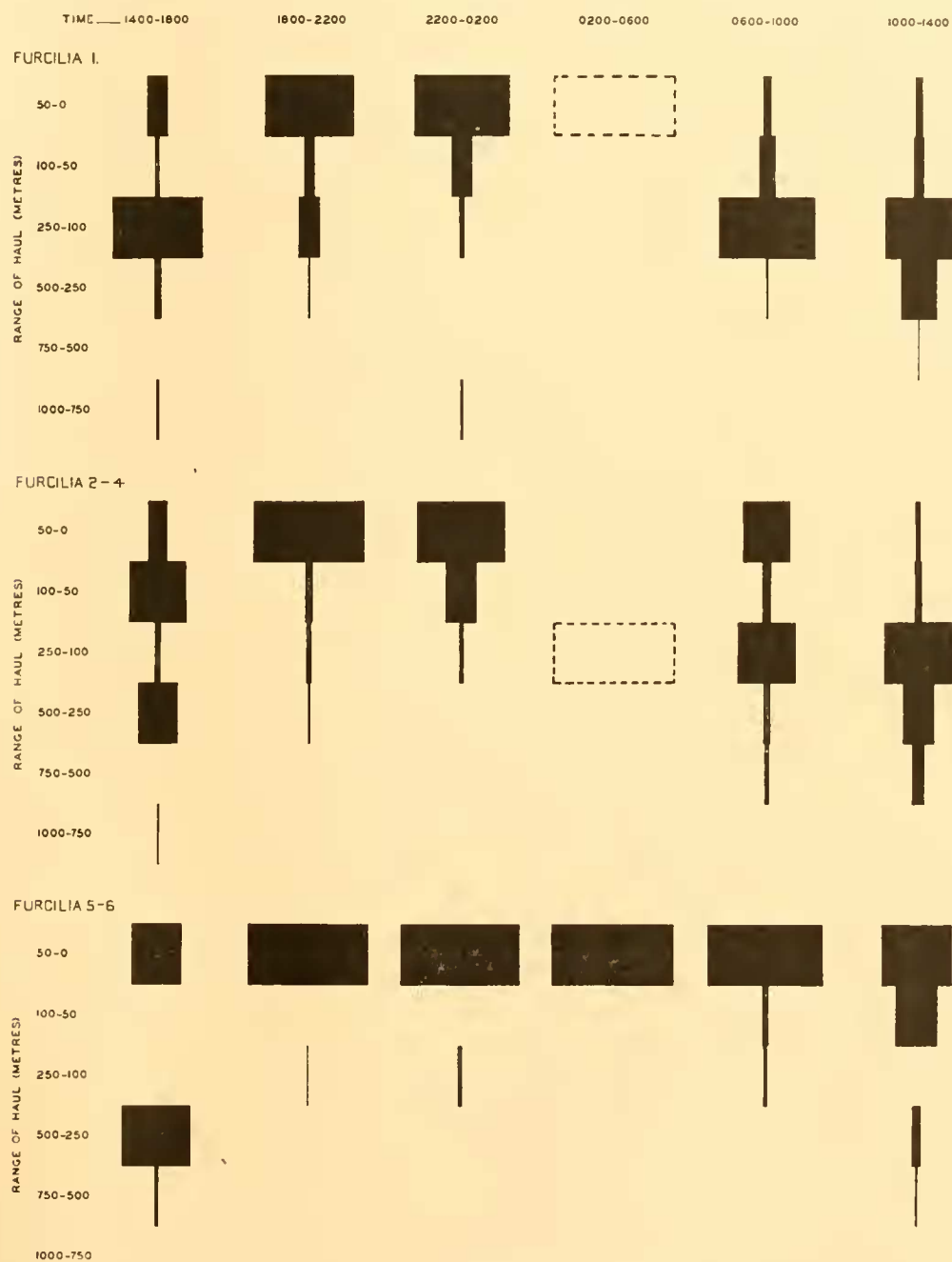


Fig. 73. Diagram showing diurnal vertical migration in Furcilia stages of *Euphausia superba*. The areas enclosed by broken lines indicate results obtained from inadequate data.

were present in greater or less abundance, from the surface down to 1000-750 m., the lowest depth to which nets were fished. In the Furcilia 5 and 6 the 750-500 m. net is the deepest in which larvae were discovered. But while it is true that the 1000-750 m.

net, and to a greater extent the 750–500 m. net, yielded larvae, yet for all stages and whatever the time of day by far the greater majority was to be found in the four uppermost nets between 500 m. and the surface.

The first three diagrams indicate very clearly the pronounced diurnal migration that is to be found in the Calyptopis stages. It is to be noted that in the period which includes midday there are still larvae to be found in the uppermost net; in Calyptopis 2, for instance, 20 per cent of the total were found in this net. Even with such proportions, however, the three diagrams show that in the daylight hours the greater bulk of the larvae is away from the surface and below 100 m., while at night they are massed in the surface water above 100 m., with a marked concentration between 50 m. and the surface noticeable in Calyptopis 2 and 3. In the daytime the mass of the larvae are between 250 and 100 m., but the appreciable percentage in the 500–250 m. net indicates that the larvae are concentrated in the lower rather than the upper portion of the 150 m. traversed by the 250–100 m. net. If this is so it means that these larvae must migrate upwards through a distance of roughly 200–250 m. to get to the surface each night.

Mention has already been made (p. 121 *supra*) of the distribution of the larvae—Calyptopis 3 predominating—in the South Georgia plankton survey in January–February 1930. It will be recalled that all the larvae were taken in the stations made beyond the 250 m. contour and that the 500–250 m. net was the deep limit for the majority.

It seems likely that light intensity, rather than temperature or salinity, is the controlling factor in the vertical distribution of the larvae, for in their daily migrations the variation experienced by the larvae in the two latter factors is that to be found in the Antarctic surface water and the warm deep water. The absence of larvae in the shallow water in the neighbourhood of South Georgia seems to indicate that there is a necessity for the larvae to seek out greater depths, so that in the daytime they may recede to them in order to obtain that degree of light intensity which is most favourable for their existence.

In the two diagrams representing Furcilia 1 and Furcilia 2–4, the paucity of data for the period 0200–0600 upsets the evenness of the curve showing diurnal migration. Of Furcilia 1 for this period two larvae only were taken, and both were in the surface net: there was one larva of Furcilia 2–4 in the 250–100 m. net. It is probable that both groups of larvae, if they were adequately represented during this four-hour period, would have their greatest concentration between 250 and 100 m. On the whole the two diagrams show, although perhaps less clearly, the same diurnal migration as is witnessed in the Calyptopis stages.

There is a noticeable difference in the last of the six diagrams, that representing Furcilia 5 and 6, compared with the five preceding it. The larvae at all times of the day, with the exception of the 1400–1800 period, are concentrated in the two uppermost net hauls. The diurnal migration of earlier stages is not evident unless the distribution of the 1400–1800 period is indicative, but whether or not this is so, the diagram shows that in twenty out of the twenty-four hours the larvae are at the surface and that below 100 m.

the frequency of occurrence is comparable to the frequency below 500 m. in earlier larval stages.

In the section of this paper dealing with the circumpolar cruise it was shown that larvae of comparable stages of development to those last mentioned were almost invariably concentrated, whatever the time of day, in the upper of two oblique nets fished. This localized distribution was most marked in the results of the June visit to the ice-edge. John states that of two nets fished, one, 1 m. in diameter, towed at a depth of 2 m., caught large numbers of larvae, whereas the other, 70 cm. in diameter, towed at 5-7 m., caught none. The process was repeated with like results. This was in close proximity to pack-ice and in the daytime. Allowance has to be made for the superior catching power of the 1-m. net, but it is quite clear that the shoals of krill were limited vertically to a range of a few feet.

It has also been mentioned already (p. 149 *supra*) that, on the course taken by the 'Discovery II' from Bouvet to South Georgia in October-November 1930, when the ship was making its way along the edge of the pack, krill was almost always to be seen at the surface in great quantity, with larval and adolescent forms predominating.

VERTICAL DISTRIBUTION AT ST. 461

An extract from the scientific log referring to this station says:

Seven hauls were made at intervals of four hours with a series of six 1-m. nets used obliquely. The oblique nets were put on the wire at intervals of 143 m. with 140 m. between the upper net and the surface. The total wire out was 855 m. The nets were hauled at $1\frac{1}{2}$ -2 knots and when the upper one had reached the surface the messenger was dispatched to close those below. Depths were determined by a depth gauge at the end of the wire and Kelvin tube near the second net from the top, the depths of the individual nets being calculated. . . . The first six hauls covering a period of twenty-four hours were taken without any hitch, but in the seventh haul one of the messengers failed to release on impact of that above and some nets were in consequence hauled open for longer than was intended.

The station was made in $56^{\circ} 44' S$, $2^{\circ} 23\frac{3}{4}' W$ to the south-west of Bouvet Island and in the vicinity of pack-ice. As might have been anticipated from the time of year, October 20-21, young *E. superba* were represented only by Furcilia 6 and small adolescents. It is noteworthy that while over eighteen and a half thousand young krill were taken in seven hauls, only 147 adults were found; of these 122 were in the G flight in the net fishing between 750 and 560 m. and closed at 315 m. The remaining adults were scattered throughout the nets of the other flights in number never more than four in any one net.

Table XL shows the quantities of young krill taken in the flights A-G. The depth of the nets and time of day are stated. The numbers show that a distinction can at once be made between the uppermost net catch of each flight and all the others. In five of the seven hauls relatively enormous quantities of krill were taken in the uppermost net, and in all seven more than 59 per cent of the total taken in each flight was in this net. In dealing with the numbers in the percentage column of the table, therefore, the figure given for the uppermost net is the percentage of the total caught in the flight of nets. For the remaining five nets the figures are the percentages of total number in those nets

but excluding the first one. The vertical distribution is shown graphically in Fig. 74, the *G* haul being omitted. Although the young euphausians preponderated at the surface they were taken in appreciable numbers in the lowest nets, 660 in the sixth net of the *C* series being the greatest. When the station was started the ship was in shoals of krill which increased in density to a maximum at the time when the *C* flight was taken. The shoals had come to an end by the time the *E* and *F* hauls were made and another one was encountered at *G*.

Considering the lower nets, II–VI, it is seen that with the approach of night there is a distinct trend upwards of the main body of the larvae and a descent again in the morning. Thus in the *A* flight, between 2.30 and 3.0 p.m., the larvae are more or less evenly distributed below 100 m.: in the *B* flight between 6.30 and 7 p.m. they are concentrated between 500 and 400 m.: in the *C* flight between 10.30 and 11 p.m. they are concentrated between 400 and 300 m.: in the *D* flight between 2.30 and 3.0 a.m. the subsurface krill has merged with the main body of the surface shoal, and in *E*, with the

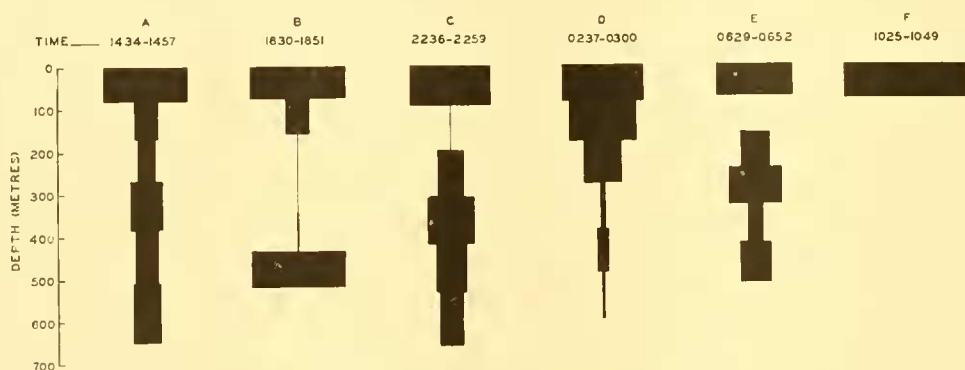


Fig. 74. Vertical distribution of young *Euphausia superba* at St. 461.

approach of daylight, there is a withdrawal of some of the krill from the surface to an ill-defined point of concentration at about 300 m.

To what are we to attribute this difference of behaviour in the larvae dividing them into the two groups, (*a*) those that remain at the surface and (*b*) those that undergo a vertical diurnal migration? There are several possible factors which might be effective, of which the following may be considered:

- (i) Differences due to ontogenetic variation in the two groups.
- (ii) Hydrographic differences.
- (iii) Seasonal changes.

(i) As Russell (1927, p. 239) points out, a species may be found to occur at a certain depth when adult, but while young it may have a different vertical distribution. Examination of the larvae from St. 461 shows that no distinction can be made between the degree of development of the surface larvae and those taken deeper down; they are a homogeneous population with Furcilia 6 and adolescents occurring in all the catches in proportions which preclude any conclusion that either stage prefers a particular water depth (see Appendix II).

(ii) There is a well-marked discontinuity below 100 m. where the cold surface water and the intermediate warm water meet. It might be suggested that this is the barrier which concentrates so large a proportion of the larvae at the surface, but examination of Table XL shows that it is apparently not a sufficiently strong obstacle to prevent the migration of the subsurface larvae which move towards, and actually merge with, the surface group in the *D* series. In this series the discontinuity is at 230 m.

Table XL. *Catches of young Euphausia superba at St. 461*

Haul ...	<i>A</i>			<i>B</i>			<i>C</i>			<i>D</i>		
Time ...	1434-1457			1830-1851			2236-2259			0237-0300		
Net	Depth	Number	Percentage	Depth	Number	Percentage	Depth	Number	Percentage	Depth	Number	Percentage
I	80-0	1450	62	75-0	2800	76	95-0	4180	64	85-0	1000	69.6
II	170-80	148	19.5	160-75	172	19.5	200-95	7	0.3	180-85	232	53
III	270-170	109	14.5	255-160	18	2	310-200	483	20.5	280-180	136	31.1
IV	385-270	193	25.4	345-255	5	0.6	420-310	864	36.7	385-280	18	4.1
V	510-385	143	18.8	440-345	27	3.1	535-420	565	24	490-385	41	9.4
VI	650-510	166	21.9	520-440	660	74.8	660-535	435	18.5	600-490	10	2.3
Total	2209			3682			6534			1437		

Table XL (cont.)

Haul ...	<i>E</i>			<i>F</i>			<i>G</i>		
Time ...	0629-0652			1025-1049			1429-1458		
Net	Depth	Number	Percentage	Depth	Number	Percentage	Depth	Number	Percentage
I	75-0	25	59.5	80-0	13	100	95-0	3584	100
II	160-75	—	—	175-80	—	—	Lower nets fouled		
III	245-160	4	23.5	270-175	—	—			
IV	330-245	7	41.1	375-270	—	—			
V	420-330	2	11.8	490-375	—	—			
VI	515-420	4	23.6	615-490	—	—			
Total	42			13			3584		
Grand total 17,501									

For the first net of each flight the percentage stated is of the total number in all six nets, for the remaining five nets the percentage is of the total number of individuals in those nets.

With the exception of the rather small numbers of *Furcilia* 5 and 6 in the 70-cm. vertical nets, the catches at St. 461 provide the only direct indication we have of vertical distribution in the later stages of development. Yet if the younger larval stages are not susceptible to the changes resulting from a vertical migration from warm to cold water and *vice versa*, it is unlikely that the older larvae would react more readily. It has been shown above that the younger larvae migrate upwards from depths greater than 250 m., involving passage from the intermediate warm water to the colder surface water. The eurythermal and euryhaline qualities of *E. superba* are fairly high, and it is considered that the presence of a discontinuity like that at St. 461 is not adequate to explain the preference of the bulk of the animals for the surface.

(iii) I feel compelled to select the third as the most important factor in the distribution of the larvae. It has been shown above that the younger larvae from Calyptopis 1 onwards have a quite well-defined diurnal vertical migration. In the last of the diagrams in Fig. 73 it was shown that the vertical migration is not pronounced and that the animals tended to remain at the surface whatever the time of day. Examination of the time of year when the larvae were taken, from which that diagram was derived, shows that about nine-tenths of the total were taken early in their second season—that is to say after the southern winter.

The winter and all it implies is, I am sure, the factor which leads to interruption of the rhythmic migrations of the euphausians. Prolonged darkness, overcast skies, low altitude of the sun and consequent increased reflection of its rays from the surface of the sea, snow falling in the very cold water and hardly melting, but predominantly the presence of pack-ice, all render it less necessary for the larvae to seek out the deeper water in daytime.

This influence of ice has been previously recognized. Russell (*loc. cit.*, p. 231) mentions the researches of Damas and Koefoed (1907) into the distribution of copepods in the Greenland Sea. They observed changes in the depth distribution according to region. "They found that species of the intermediate and deep layers were met with in the ice covered western part of the Greenland Sea at much higher levels than in the eastern uncovered portion. They further, on an examination of the hydrographic data, concluded that this difference was not occasioned by currents and had no relation with salinity or temperature."

Damas and Koefoed indicate that the light intensity is the important factor.

Römer (1904, p. 72), cited in the same paper by Russell (p. 256) states: "In the warmer ice-free waters of the west coast (of Spitzbergen) the difference between the scarceness of plankton in the surface layers in the daytime and its abundance in the evening and at night is much more marked than below the thick pack-ice of the eastern region. It is most probable that this is due to the strong cutting off of the light rays by the ice." It is likely that similar conditions produce like results in *E. superba* and explain the abundance in which it is found in the vicinity of ice fields.

In addition, however, to pack-ice affecting light intensity there is another way in which it probably helps in the formation of shoals of krill. If we assume that in ice-free

water, before the coming of the cold conditions of winter, the larval krill is more or less evenly distributed, or even if it is in small swarms of individuals which have developed from the same brood, in its migrations upwards to the surface it will be fairly evenly distributed in the surface water. But when pancake-ice is formed and, later, pack-ice, the cutting off of the light rays necessary for photosynthetic processes will diminish the production of diatoms underneath the ice and there will be a movement of the krill to areas of greater abundance of food at the periphery of the ice-field. That this happens is proved by observations on the circumpolar cruise and the voyage which the 'William Scoresby' made into the Weddell Sea (see pp. 137, 148). The latter instance is most striking because the ship penetrated far into an area which is normally ice-covered for the greater part of the year, and the stations where krill was taken are all concentrated on the northern part of the line between South Georgia and the point east of the South Sandwich Group, where the ship turned southwards into the water of the eastern Weddell Sea. No krill was taken in the part of the Weddell Sea which is normally ice-covered, although the observations included a station at the ice-edge with hauls throughout a twenty-four-hour period (St. WS 552). It cannot be doubted that krill does not penetrate far beyond the edge of the ice-field, and that to some extent at any rate the concentrations met with in the vicinity of the pack are caused by the movement, towards the periphery of the pack, of krill which was more uniformly distributed before the formation of the ice-field.

An explanation is required however to account for the persistence of some of the krill in a vertical migration towards the surface at night. Russell (1927, p. 235), quoting Michael's results (1911, p. 144) of investigations into the vertical distribution of certain Chaetognatha, states:

All individuals do not react towards light, temperature and salinity in the same way. While the majority migrate towards the surface during twilight hours and toward deeper water during intense light and darkness, a few almost always remain in deeper water during twilight and on the surface during intense light and darkness. Similar individual differences occur with respect to temperature and salinity. This means that those optimum conditions favourable to the species as a whole are not favourable to each individual or in other words the characteristic organization, constitution or physiological state of each individual modifies the effect of light, temperature and salinity on its behaviour.

The principle involved in the foregoing quotation can be applied to *E. superba*, although there is a modification in behaviour. At the time of year we are considering the optimum conditions for the greater part of the krill are at the surface, but for the rest they are at a variable distance from the surface dependent on the time of day. Now it has already been pointed out that, even in the Calyptopis stages where there is a pronounced diurnal migration, there are still appreciable numbers of larvae to be found at the surface at midday. In the later larvae with which we are dealing the predilection for the surface has become emphasized. To this extent the difference in distribution may be ontogenetic in origin, simply because the time of year when Furcilia 6 and adolescents are predominant coincides with the period of winter conditions and concomitant alteration in light intensity.

It may be that at St. 461 the animals which undergo a diurnal vertical migration are still influenced by light intensity to a greater extent than those remaining at the surface, or it may be that their movements indicate the last vestiges of a physiological rhythm acquired in earlier larval history and persisting when the stimulus which originally promoted it is no longer active. This may be so, but the important fact is that with adolescence there is an abandonment of diurnal migration, and whereas the majority of the larvae from Calyptopis 1 to Furcilia 5 undergo a rhythmic alteration in vertical position the adolescents are persistently at the surface.

The significance of this distribution is that it affects the distribution of krill in the Antarctic, but before dealing with this the general water movements within the Antarctic should be recalled. Deacon (1933, p. 226 *et seq.*) states:

The movement of Antarctic surface water away from the Antarctic regions towards the north is known to take place all round the Pole and it is also known that there is a similar movement of Antarctic bottom water towards the north near the sea-bottom. To make up for this transport of water away from the Antarctic regions in the surface and bottom layers there must be a movement towards the Pole in the intermediate layer. This is supplied by a movement southwards in the warm deep layer.... There can be no doubt that the water at the level of maximum temperature in the Antarctic Zone has a component of movement southwards.

Again on p. 173:

In the Antarctic Zone the surface layer is composed of cold poorly saline water which lies in a shallow well-defined layer above warmer deep water. It has a depth of 100–250 m.

The discontinuity is shallower in the south than in the north. The observed occurrence of *E. superba* in this system of currents having components of direction opposed to one another is worth considering. It has been shown that eggs, Nauplii and Metanauplii are taken in greatest abundance in the deeper water, their component of movement will therefore be southwards. Calyptopis and early Furcilia have a diurnal vertical migration which brings them into the north-flowing surface water during the hours of darkness but which returns them to the south-flowing deep water in the daytime. Their component of movement will therefore be dependent on the time spent in each water layer each day and on the rates of movement of the two water-masses. The accumulation of late Furcilia and adolescents at the ice-edge would suggest that the resultant direction of movement of the larvae is generally in a southerly direction. The late Furcilia and adolescents, as we have just shown, are surface-loving in their habit, and they will be borne northwards in the surface water of the Antarctic streaming away from the Pole. The distribution of adults does not come within the scope of this paper, but it may be anticipated that they would be found more generally distributed between the Antarctic convergence and the ice-edge than are the adolescents. For instance, at St. 461 in the *A* flight of nets there were 9220 Furcilia and adolescents, but only 2 adults; in the *B* flight 3682 Furcilia and adolescents, with 4 adults; for *C* the figures are 6534 and 10, for *D* 1437 and 9, for *E* 42 and none, for *F* 13 and none, and for *G* 3584 and 122. There is no indication at this station of adult krill in quantity in any way indicative of the vast shoals which occur elsewhere. Again at the stations succeeding 461 along the ice-edge,

although adults certainly were taken they nowhere occurred in quantity approaching that in which larvae and adolescents were found.

TIME DISTRIBUTION

In Fig. 75 is shown the range in time of the different stages of development. The time ranges for the occurrence of eggs, Nauplii and Metanauplius have already been discussed, but they have been inserted in the diagram to show them in relation to later stages. For each stage represented in the diagram there are six horizontal divisions indicating the six seasons from which data have been obtained: thus the lowest division

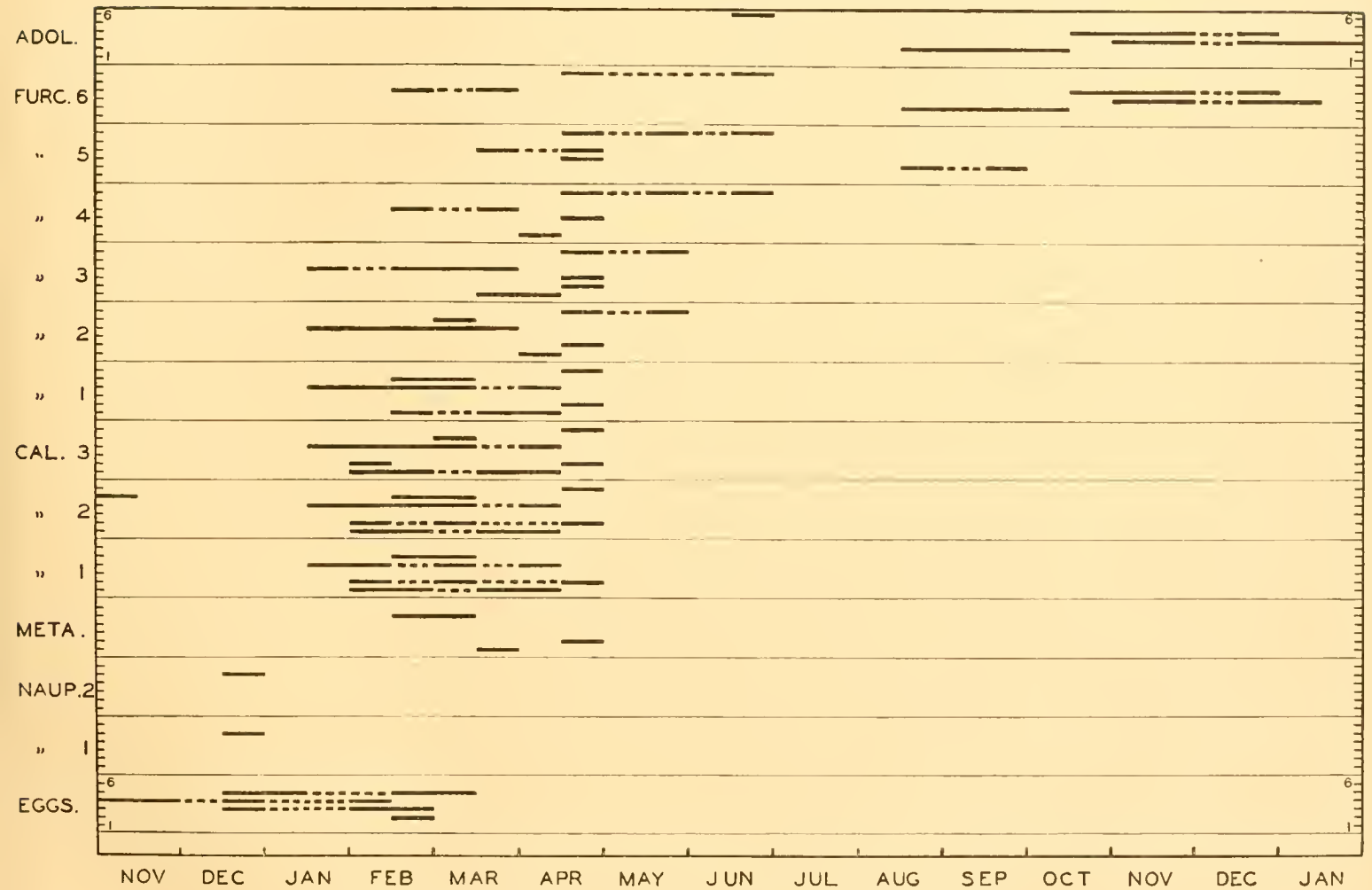


Fig. 75. Seasonal distribution of developmental stages of *Euphausia superba*.

represents the season 1926-7 and the uppermost the season 1931-2. For most of the seasons observations ended with the end of the southern summer, and for the months of May to mid-August the records of the occurrence of young krill are entirely derived from the circumpolar cruise collections. It is for this reason that there is an apparent abrupt termination in the occurrence of Metanauplius, Calyptopis and Furcilia 1 and 2. The continuous line indicates half-months in which larvae were found; the dotted lines

connecting continuous lines are intervening periods between half-months in which larvae were found, and during which periods it may be assumed that they would be likely to occur.

The figure shows that from the second half of January onwards to the end of April at any rate, stages from Calyptopis 1 to Furcilia 1 are to be found. There is a single record of a Calyptopis 2 in the first half of November which, I consider, must be regarded as an exception. There is no general incidence of early larvae until the second half of January, and their absence in the May observations of the circumpolar cruise indicates that the stages up to Furcilia 1 are passed through before the coming of winter conditions. Furcilia 2 and 3, like earlier stages, occur in the second half of January and are the youngest forms found in May; their time range is therefore four and a half months. The first records of Furcilia 4 and 6 are not obtained until the second half of February. Furcilia 5 has no record before the second half of March, but it must, of course, occur at a time preceding the first occurrence of the ensuing stage. Furcilia 4 is found in June, so that like Furcilia 2 and 3 it has a time range of four and a half months but with its first record a month later than the previous stages.

Furcilia 5 has a considerably longer time range of occurrence, for from March onwards it is found until the end of the southern winter in September. It should be pointed out, however, that Furcilia 5 occurs only in extremely small numbers in the August-September catches (see Appendix I, Sts. WS 259, 261-263, 266, 268 and 286). Furcilia 6 has by far the greatest period of occurrence. The first record is in the latter half of February and the last in the first half of January, a period of eleven months; but from November to January (see Appendix), where numbers in the samples are large enough to give a reliable indication, Furcilia 6 is a very small and insignificant constituent of the krill population.

In the diagram the occurrence of adolescents is traced from the first record in June to the time in January when the euphausian becomes of such a size that determination of the state of maturity and distinction from the previous year class is an anatomical problem not to be dealt with here.

The extended period during which Furcilia 6 is represented is in part due to the intervention of winter, during which growth is retarded and developmental processes slowed down. But there is no doubt that the extended period of occurrence is to some extent apparent rather than real. There is no clear line of demarcation between Furcilia 6 and adolescent; the character used to recognize the former stage, namely the presence of three postero-lateral spines and one terminal spine on the telson, is one which can be possessed by larvae within a very wide range of size. If, as is the case, it is possible for *E. superba* to be sexually mature while still lacking its full structural development, it is quite likely that forms recognized as Furcilia 6 may in fact be more properly classed as adolescent. In time distribution, as in development, later stages become less capable of narrow definition. The significant point ecologically is that this extension of the time occurrence of well-advanced krill ensures a constant food supply for the whales in Antarctic waters.

GENERAL REMARKS ON DISTRIBUTION

Notwithstanding the fact that the records of the occurrence of eggs indicate that *E. superba* prefers the far south for spawning, the place where eggs were taken differs widely from those where Metanauplii and Calyptopis 1 were taken. It is felt that concentrations of eggs, which were found in the Bransfield Strait, almost to the exclusion of other localities, must be due to the peculiar hydrographic and bathymetric in that region. The distribution of Metanauplius and Calyptopis 1 (Figs. 32, 76) indicates that these forms have no immediate relation to the occurrence of pack-ice nor are they restricted to the southern parts of the Antarctic. In the west of the Scotia Sea Metanauplii extend to the north almost to the Antarctic convergence. To the east, westward

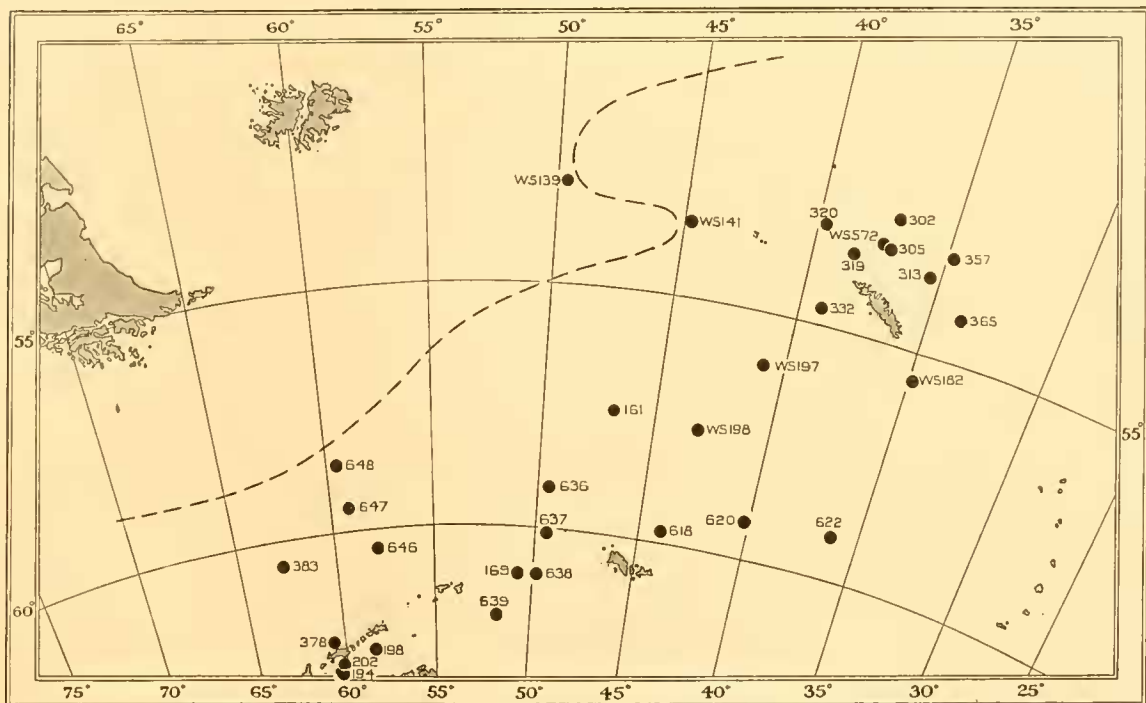


Fig. 76. Distribution of *Euphausia superba*, 1st Calyptopis.

of South Georgia, at St. WS 197 where 115 were taken, they are found at a time of year, the second half of April, when ice is far to the southward. Similarly Calyptopis 1 is so scattered in its distribution that no correlation with pack-ice can be obtained. The time between the laying of eggs and their development into Calyptopis 1 is assumed to be comparatively short, so that the distribution of stages up to this point should be approximately the same as that of the spawning adults. When the larva reaches Calyptopis 1 the vertical migration already noted in this and subsequent stages will affect the regional distribution.

If spawning took place at the surface in proximity to ice we would expect to find that increasing advancement of development in the larvae would be correlated with increasing distance from the regions where pack-ice is abundant, but nothing of this nature is shown in the material examined. Investigation of the adults and the occur-

rence of gravid females should indicate whether there is a concentration of the latter in the region of pack-ice. The few records of gravid females in the present material show that some were taken off the coast of South Georgia (St. 356), some in the Bransfield Strait (St. 548), some off the Biscoe Islands (St. 602), and some at a point about midway between South Georgia and the South Orkneys (St. WS 376). Although the records are admittedly small, yet such as exist are very widely scattered and give no indication of concentration in any particular locality.

The scarcity of adult *E. superba* as compared with adolescents along the edge of the pack, demonstrated by the catches in the line of stations from Bouvet westwards to South Georgia and in the South Georgia survey succeeding it in October–November 1930 (p. 149), shows that it is not at the ice-edge that one would expect to find them. The numbers for the stations instanced are as follows: adults 869; adolescents, including *Furcilia* 6, 195, 164. The scarcity of adult *E. superba* at the ice-edge stations of the circumpolar cruise has been noted by John. The ice-edge is predominantly and almost exclusively the locus of adolescent krill and not of adult krill, at any rate at this time of year just prior to that when spawning is believed to commence.

It has been shown that this adolescent krill stays in the surface water which is moving away from the Pole, so that it will be borne northwards in the Antarctic surface water towards the Antarctic convergence.

It may be noted here that the whalers speak of Blue whale krill and Fin whale krill to describe respectively adolescent and adult *E. superba*. Ruud (1932, p. 46) says:

There seems to be an undoubted correlation on the one hand of abundant drift ice with abundant Blue whales and krill of Group I [i.e. adolescents] and on the other hand of a small quantity of drift ice with abundant Fin whales and krill of Group II [i.e. adults].

If *E. superba* spawns under and near the drift ice its spawning ground is the zone of the pack ice and as a rule the conditions off South Georgia are not suitable for its spawning. The stock of krill at South Georgia must therefore be carried thither by the current in the Antarctic surface layer. When the newly hatched larvae drift out of the Weddell Sea with the ice they gradually develop and grow in conformity with the curve of growth with which we are familiar. Group I may be found comparatively far from the actual spawning ground but still near the ice; farther away, near the extreme limits of the distribution of *E. superba* and at a distance from the ice there will be only Group II. When there is little ice at South Georgia we only find Group II but with a great deal of ice there is also a large proportion of Group I. The Blue whale is a more typical ice whale than the Finner, hence the correlation of abundant ice, krill of Group I and Blue whales—and of a small quantity of ice, krill of Group II and an abundance of Fin whales.

Owing to the rotatory motion of the surface current in the Weddell Sea and other parts of the Antarctic, the central spawning ground of the krill in the drift ice zone will always be supplied with an ample stock of animals of Group II—sufficient to produce a large stock of larvae when they spawn.

In the light of the present data, it is necessary to make some modification in the conception of the mechanism by which the return of the krill to the south is brought about.

The hydrological evidence of a complete rotatory surface movement in the horizontal plane is very scanty. One would expect that a well-defined and constantly flowing current southwards would be required to bring about the replenishment of *E. superba*

necessary to ensure a continuance of the abundance in which it is found in Antarctic waters. Deacon (1936, p. 19) says:

The movement towards the west, the northward current along the east coast of Graham Land, and the current flowing out of the Weddell Sea towards the east, form three parts of a cyclonic movement which extends across the entire width of the Atlantic Ocean. The surface temperature distribution suggests that the cyclonic movement may be completed by a southward movement between 20° and 30° E; there is, however, very little evidence of such a current at the surface, although its existence in the warm deep layer cannot be doubted.

Ruud's scheme does not take into account the predominance of eggs and Metanauplius in the region of the warm deep water, which has a component of direction southwards, not northwards, neither do his data give information about diurnal migration in the Calyptopis and early Furcilia stages. Two items of negative evidence should also be considered—the great scarcity of adult krill at the ice-edge at the beginning of the summer season and the lack of eggs in the proximity of field-ice in number in any way approaching that obtained, for instance, at St. 540. The fact that krill does not occur far inwards from the peripheral region of field-ice is also important.

The present results suggest that replenishment of the stock of krill is assured by a rotary movement involving the northward flowing surface water, the southward-flowing deep water and the distribution and migrations of krill within these currents.

The accumulation of adolescents at the ice-edge can then be accounted for by suggesting that the resultant direction of movement in the eggs and in Metanauplius to early Furcilia stages has a southerly component. The periphery of the ice-field is the southern limit for the larvae, where they will tend to be massed together. This shoaling is probably assisted also by the increase in area of the ice-field with the advent of winter conditions and the freezing of the sea, leading to a further accumulation at the ice-edge of larvae which were formerly in ice-free water.

The habitat of the late Furcilia and early adolescents is at the surface and predominantly at the ice-edge. They will spread northwards in the northerly flowing surface water, with the breaking up and drifting away of the field-ice in the spring and summer. The adults, as Ruud points out, will be found at a distance from the ice. From the records of the deep occurrence of eggs and early larval stages it is considered more probable that they, rather than the adults returned to the south by the rotary motion of the surface currents, are responsible for the replenishment of the stock of adolescents at the ice-edge.

The absence of adult krill in any abundance at the ice-edge, at a time just prior to that when spawning is supposed to commence, negatives the assumption that they are brought back to the drift-ice zone by rotary motion of the surface currents. At any rate, if it is admitted that adolescents are predominantly at the surface and if this position is maintained until the adult state is reached, it means that for about a year they are in water which has a resultant component of direction northwards. In such a period of time they would be carried far away from the ice-edge towards the Antarctic convergence.

SUMMARY

1. The egg, Nauplius, Metanauplius and Calyptopis stages of *Euphausia superba* have been described—Nauplius 2 for the first time (p. 17).

2. The nature of Furcilia stages in Euphausiacea has been discussed. The suggestion is advanced that, in the light of the data supplied by the present material and the interpretation of known larval histories in conjunction with these results, the actual number of stages in early Furcilia development is much smaller than previously acknowledged (p. 32).

3. A division is made of larvae with all pleopods setose and seven terminal spines on the telson into two Furcilia stages: (a) those that on moulting are again seven-spined, (b) those that on moulting are five-spined (p. 41).

4. Reasons are given for abandoning the term Cyrtopia (p. 50).

5. Later larval development is diffuse and ill-defined and individual variation is great (p. 51).

6. Anatomical descriptions of Furcilia stages are given to indicate the general trend of development (p. 68).

7. The term adolescent as used in this report is defined and the indistinctness of this phase emphasized (p. 99).

8. Anomalous length frequencies are discussed and reasons suggested why some of the larvae in their second season are so much larger than the majority. A correlation between large size and phytoplankton distribution is given, but doubt is expressed whether the correlation is a direct one or due to a community of conditions affecting phytoplankton in abundance and euphausians in length (p. 103).

9. The average lengths of earlier larvae indicate that the young euphausian reaches a length of about 10 mm. by the end of its first summer season (p. 106).

10. In the first year or fourteen months *E. superba* reaches a length of over 24 mm. Growth is not regular, being slowed down during the winter months (p. 107).

11. The distribution of eggs, Nauplii and Metanauplius shows that these stages are found in deep rather than shallow water. Regionally the majority of the eggs have been found in the Bransfield Strait, but Metanauplii are widely spread throughout the Scotia Sea. The second half of the summer season is the time when eggs, Nauplii and Metanauplius are to be found (p. 109).

12. The distribution of Calyptopis and Furcilia stages is described, and the general impression obtained is that in the Falkland sector at any rate no well-defined predilection for the immediate vicinity of ice can be demonstrated (p. 117).

13. The ice-edge distribution of Furcilia 6 and adolescents is made clear, especially by the results obtained from the circumpolar cruise stations and a line of stations from Bouvet to South Georgia early in the summer season (p. 137).

14. The vertical distribution and migrations of young *E. superba* are described and the distinction made between early stages which have a well-defined diurnal vertical migration and the adolescents which remain continuously at the surface (p. 151).

15. The time distribution of larvae and adolescents shows that with advancing development there is a lengthening of time of occurrence. This is another way of expressing the increasingly indefinite nature of the process of development. The wide range of time within which older forms are found is important ecologically as it ensures a constant supply of food for the whalebone whales in the south. Eggs are found over a period of four and a half months in the earlier part of the southern summer season. Calyptopis and early Furcilia predominate from January onwards and are not found at the beginning of the next summer season. Later Furcilia forms are prominent in the second half of the summer season and a few are found after the winter. Furcilia 6 originates, generally speaking, late in the summer season and has an extended period of occurrence carrying it midway into the summer season following hatching. Adolescents have a still more extended period of occurrence, the complete range of which is not within the scope of the present paper (p. 161).

16. It is postulated that in the light of the information obtained concerning

(a) Deep distribution of eggs, Nauplii and Metanauplius,

(b) Diurnal migration of Calyptopis and early Furcilia in warm deep water and Antarctic surface water,

(c) Persistent occurrence of adolescents at the surface,

that the continued abundance of *E. superba* in Antarctic waters and the replenishment of the stock of adolescents at the ice-edge is brought about by the rotary movement resulting from the assemblage of the earlier developmental stages chiefly in the southward flowing warm deep water and that of the later stages in the northward flowing Antarctic surface water. This movement is suggested as an alternative to the hypothesis which involves the return of adults to the ice-edge by rotary movements in the surface water alone (p. 163).

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APPENDIX I

Length frequencies and average lengths of late Furcilia forms and early adolescents taken in the 1-m. nets

Station Date	...	...	WS 254 22. viii. 28			WS 255 22-23. viii. 28			WS 256 23-24. viii. 28			WS 257 27. viii. 28			WS 258 27. viii. 28			WS 259 27-28. viii. 28		
Length mm.			Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 5	Furcilia 6	Adolescent	Total		
6.5-7.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1		
7.0-7.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
7.5-8.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
8.0-8.5	—	—	—	—	—	1	—	1	2	—	2	—	—	—	—	1	—	1		
8.5-9.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3		
9.0-9.5	—	—	—	—	—	—	—	—	5	—	5	—	—	—	—	3	—	3		
9.5-10.0	—	—	—	—	—	1	—	1	6	—	6	—	—	—	—	3	—	3		
10.0-10.5	—	—	—	—	—	—	—	—	4	—	4	1	—	1	—	3	—	3		
10.5-11.0	1	—	1	—	1	1	—	1	4	—	4	1	—	1	—	4	1	5		
11.0-11.5	1	—	1	—	1	—	—	—	—	—	—	—	—	—	—	1	1	2		
11.5-12.0	2	2	4	—	—	—	—	1	—	1	1	—	—	—	—	2	2	4		
12.0-12.5	1	2	3	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—		
12.5-13.0	—	1	1	—	—	—	1	1	2	—	2	—	—	—	—	—	—	—		
13.0-13.5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
13.5-14.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1		
14.0-14.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
14.5-15.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
15.0-15.5	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—		
Total	5	6	11	—	—	3	24	6	30	1	—	1	5	1	6	1	21	5	27	
Percentage	45.5	54.5	—	—	—	—	80	20	—	100	—	—	83.3	16.7	—	3.7	77.7	18.5	—	
Av. length, mm.	11.55	12.33	—	—	—	9.81	13.25	—	—	10.25	—	—	11.25	12.75	—	6.75	10.06	11.85	—	
Gen. av., mm.	11.98			9.58			10.50			10.25			11.50			10.26				
Total in sample	12			3			30			1			6			112				

DISCOVERY REPORTS

Station Date	WS 260 28. viii. 28			WS 261 28. viii. 28			WS 262 28. viii. 28			WS 263 28. viii. 28			WS 264 28. viii. 28			WS 265 29. viii. 28		
	Furcilia 6	Adolescent	Total	Furcilia 5	Furcilia 6	Total	Furcilia 5	Furcilia 6	Total	Furcilia 5	Furcilia 6	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
Length mm.																		
6.5-7.0	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—
7.0-7.5	—	—	—	1	—	1	3	—	3	—	—	—	—	—	—	—	—	—
7.5-8.0	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
8.0-8.5	—	—	—	4	1	5	—	2	2	3	3	1	1	—	1	1	—	1
8.5-9.0	2	—	2	1	5	6	—	3	3	6	9	3	4	—	4	1	—	1
9.0-9.5	3	—	3	—	5	5	—	4	4	8	10	6	5	—	5	1	—	1
9.5-10.0	3	—	3	—	5	5	—	3	3	6	17	10	6	—	6	—	—	—
10.0-10.5	2	—	2	—	10	10	—	2	2	12	13	17	5	—	5	1	—	1
10.5-11.0	3	—	3	—	14	14	—	2	2	16	11	12	5	—	5	—	—	—
11.0-11.5	2	—	2	—	10	10	—	2	2	12	13	15	3	2	3	2	—	2
11.5-12.0	1	2	3	—	6	3	—	1	1	7	7	12	5	2	7	—	—	—
12.0-12.5	—	2	2	—	10	4	—	—	—	4	4	8	4	—	4	—	—	—
12.5-13.0	1	—	1	—	4	3	—	—	—	3	3	6	3	—	3	—	—	1
13.0-13.5	—	1	1	—	3	1	—	—	—	1	1	2	1	—	1	—	—	1
13.5-14.0	—	—	—	—	1	3	—	—	—	—	—	—	—	1	1	—	—	1
14.0-14.5	—	—	—	—	1	2	—	—	—	—	—	—	—	2	2	—	—	2
14.5-15.0	—	—	—	—	1	1	—	—	—	—	—	—	1	1	1	—	—	1
15.0-15.5	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
15.5-16.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	17	5	22	6	75	18	4	19	23	77	17	94	35	10	45	7	2	9
Percentage	77.3	22.7	—	6.1	75.7	18.2	17.4	82.6	—	81.9	18.1	—	77.8	22.2	—	77.8	22.2	—
Av. length, mm.	10.25	12.25	—	8.16	10.99	13.08	7.13	9.75	—	10.61	12.19	—	10.24	12.75	—	9.89	13.25	—
Gen. av., mm.	10.70			11.2			9.29			10.89			10.79			10.64		
Total in sample	22			243			26			384			52			11		

APPENDIX I

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Station Date	WS 266 29. viii. 28				WS 267 29. viii. 28			WS 268 29. viii. 28				WS 269 30. viii. 28			WS 270 30. viii. 28		WS 271 30. viii. 28	
Length mm.	Furcilia 5	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 5	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6
7.0-7.5	—	—	—	—	2	—	2	1	—	—	1	—	—	—	—	—	—	—
7.5-8.0	2	—	—	2	2	—	2	—	1	—	1	—	—	—	1	—	—	—
8.0-8.5	—	—	—	2	8	—	8	—	3	—	3	—	—	—	1	—	—	—
8.5-9.0	—	3	—	3	16	—	16	—	6	—	6	1	—	1	1	—	—	—
9.0-9.5	—	6	—	6	17	—	17	—	8	—	8	—	—	—	—	—	—	—
9.5-10.0	—	4	—	4	13	—	13	—	7	—	7	—	—	—	—	—	—	—
10.0-10.5	—	6	—	6	8	—	8	—	8	—	8	1	—	2	2	—	—	1
10.5-11.0	—	7	1	8	5	1	6	—	6	—	6	—	1	1	1	—	—	1
11.0-11.5	—	—	—	—	5	1	6	—	3	—	3	—	1	1	—	—	—	—
11.5-12.0	—	2	1	3	2	2	4	—	3	—	3	—	1	2	2	—	—	—
12.0-12.5	—	—	1	1	1	3	4	—	2	—	2	—	2	—	—	—	—	—
12.5-13.0	—	—	3	3	—	2	2	—	—	—	2	—	2	2	—	—	—	—
13.0-13.5	—	—	1	1	—	3	3	—	—	—	1	—	—	—	—	—	—	—
13.5-14.0	—	—	5	5	—	3	3	—	—	—	—	—	—	—	—	—	—	—
14.0-14.5	—	—	4	4	—	2	2	—	—	—	—	—	—	—	—	—	—	—
14.5-15.0	—	—	3	3	—	1	1	—	—	—	—	—	—	—	—	—	—	—
15.0-15.5	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—
15.5-16.0	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16.0-16.5	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—
Total	2	30	20	52	79	21	100	1	47	11	59	2	7	9	8	2	2	2
Percentage	3.8	57.7	38.5	—	79	21	—	1.6	79.6	18.6	—	22.2	77.7	—	80	20	100	—
Av. length, mm.	7.75	9.92	13.6	—	9.47	13.25	—	7.25	9.94	12.2	—	9.5	11.82	—	9.94	13.00	10.25	—
Gen. av., mm.	11.24				10.26			10.4				11.30			10.55		10.25	
Total in sample	113				120			70				12			11		3	

DISCOVERY REPORTS

Station Date	...	WS 272 30. viii. 28	WS 273 4. ix. 28	WS 274 4. ix. 28	WS 276 4. ix. 28	WS 278 12. ix. 28	WS 279 13. ix. 28	WS 280 17. ix. 28
Length mm.		Furcilia 6 Total	Furcilia 6 Total	Furcilia 6 Total	Furcilia 6 Adolescent Total	Furcilia 6 Adolescent Total	Furcilia 6 Adolescent Total	Furcilia 6 Adolescent Total
7.5-8.0		—	—	—	1	—	—	—
8.0-8.5		—	—	1	—	—	—	—
8.5-9.0		—	—	1	—	—	—	—
9.0-9.5		—	—	1	—	—	—	—
9.5-10.0		—	—	—	4	—	—	—
10.0-10.5		—	—	—	1	—	—	—
10.5-11.0		—	—	—	8	—	—	—
11.0-11.5		—	1	—	1	—	—	—
11.5-12.0		—	—	—	7	—	—	—
12.0-12.5		—	—	—	3	—	—	—
12.5-13.0		—	—	—	6	—	—	—
13.0-13.5		1	—	—	1	—	—	—
13.5-14.0		—	—	—	3	—	—	—
14.0-14.5		—	—	—	2	—	—	—
14.5-15.0		—	—	—	1	—	—	—
15.0-15.5		—	—	—	—	—	—	—
15.5-16.0		—	—	—	—	—	—	—
16.0-16.5		—	—	—	—	—	—	—
Total		1	1	1	59	6	100	26
Percentage		100	100	100	25	40	35	24
Av. length, mm.		12.75	11.25	8.25	42.4	13.92	13.55	48
Gen. av., mm.		12.75	11.25	8.25	11.47	12.58	12.37	12.06
Total in sample		1	1	1	98	16	163	58

Station Date	...	WS 281 17. ix. 28			WS 282 17. ix. 28			WS 283 17. ix. 28			WS 284 18. ix. 28			WS 285 18. ix. 28			WS 286 18. ix. 28			
Length mm.	...	Total		Furcilia 6	Total		Furcilia 6	Total		Furcilia 6	Total		Furcilia 5	Furcilia 6	Adolescent	Total	Furcilia 5	Furcilia 6	Adolescent	Total
		Adolescent	Furcilia 6		Adolescent	Furcilia 6		Adolescent	Furcilia 6		Adolescent	Furcilia 6								
7.5- 8.0		—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	1
8.0- 8.5		—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	1
8.5- 9.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
9.0- 9.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—
9.5-10.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—
10.0-10.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	—	—
10.5-11.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—
11.0-11.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	—	—
11.5-12.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—
12.0-12.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—
12.5-13.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—
13.0-13.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—
13.5-14.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—
14.0-14.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—
14.5-15.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—
15.0-15.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	—	—
15.5-16.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
16.0-16.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
16.5-17.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—
17.0-17.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—
17.5-18.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18.0-18.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total		15	19	34	33	67	100	25	75	100	2	1	3	60	40	100	2	57	41	100
Percentage		44.1	55.9	—	33	67	—	25	75	—	66.7	33.3	—	60	40	—	2	57	41	—
Av. length, mm.		12.52	14.25	—	12.78	15.24	—	12.27	14.88	—	12.25	16.25	—	11.38	12.9	—	8.0	11.35	13.6	—
Gen. av., mm.		13.43			14.43			14.23			13.58			11.99			12.2			
Total in sample		37			456			440			15			1600			900			

DISCOVERY REPORTS

Station Date	...	WS 287 19. ix. 28			WS 288 19. ix. 28			WS 291 2. x. 28		WS 292 3. x. 28			WS 293 3. x. 28		WS 294 3. x. 28		WS 295 3-4. x. 28		
		Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total
8.5-9.0		1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.0-9.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.5-10.0		2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.0-10.5		5	—	5	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—
10.5-11.0		3	—	3	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—
11.0-11.5		13	1	14	5	—	5	—	—	—	—	—	—	—	—	—	—	—	—
11.5-12.0		16	5	21	10	2	12	—	1	—	—	—	—	—	—	—	—	—	—
12.0-12.5		10	6	16	10	2	12	—	—	—	—	—	—	—	—	—	—	—	—
12.5-13.0		7	11	18	7	8	15	—	—	—	—	—	—	—	—	—	—	—	—
13.0-13.5		3	10	13	4	9	13	—	—	—	—	—	—	—	—	—	—	—	—
13.5-14.0		—	6	6	2	12	14	—	—	—	—	—	—	—	—	—	—	—	—
14.0-14.5		—	2	2	1	8	9	1	1	—	—	—	—	—	—	—	—	—	—
14.5-15.0		—	1	1	1	7	8	—	—	—	—	—	—	—	—	—	—	—	—
15.0-15.5		—	—	—	—	5	5	—	—	—	—	—	—	—	—	—	—	—	—
15.5-16.0		—	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—
16.0-16.5		—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
16.5-17.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17.0-17.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17.5-18.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18.0-18.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18.5-19.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19.0-19.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19.5-20.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20.0-20.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20.5-21.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21.0-21.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21.5-22.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total		60	42	102	44	56	100	1	1	2	3	5	1	1	24	24	5	95	100
Percentage		58.8	41.2	—	44	56	—	100	—	40	60	—	100	—	100	—	5	95	—
Av. length, mm.		11.63	12.9	—	12.22	13.85	—	14.25	—	12.0	15.92	—	17.75	—	16.63	—	13.75	16.48	—
Gen. av., mm.		12.15			13.13			14.25		14.35			17.75		16.63		16.35		
Total in sample		108			20,440			1		5			1		24		412		

Station Date	...	...	WS 296 4. x. 28			WS 297 4. x. 28			WS 298 5. x. 28			WS 299 5. x. 28			WS 300 5. x. 28			WS 301 5. x. 28		
Length mm.	WS 296 4. x. 28		WS 297 4. x. 28		Total	WS 298 5. x. 28		Total	WS 299 5. x. 28		Total	WS 300 5. x. 28		Total	WS 301 5. x. 28		Total			
	Furcilia 6	Adolescent	Furcilia 6	Adolescent		Furcilia 6	Adolescent		Furcilia 6	Adolescent		Furcilia 6	Adolescent							
10.0-10.5	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—			
10.5-11.0	—	—	—	—	1	—	—	—	—	—	—	2	—	2	—	—	—			
11.0-11.5	—	—	—	—	1	—	—	—	—	—	—	3	—	3	—	—	—			
11.5-12.0	3	—	2	—	2	1	—	1	2	—	2	5	1	6	1	—	1			
12.0-12.5	3	—	4	1	5	—	—	—	2	1	2	3	3	6	3	2	2			
12.5-13.0	2	1	3	3	6	—	—	—	3	3	5	6	2	8	2	2	5			
13.0-13.5	—	1	1	6	7	—	—	—	4	6	10	9	5	11	1	3	8			
13.5-14.0	—	2	1	8	9	—	—	—	5	4	9	4	10	14	3	5	5			
14.0-14.5	2	5	1	9	10	1	—	1	2	12	14	3	8	11	1	4	3			
14.5-15.0	—	10	1	8	9	—	—	—	—	10	10	1	6	7	—	3	3			
15.0-15.5	—	10	1	9	10	—	—	—	—	10	10	—	9	8	1	8	9			
15.5-16.0	1	13	—	3	3	—	—	—	—	23	23	—	7	9	1	8	8			
16.0-16.5	—	13	—	3	3	—	—	—	—	5	5	1	4	8	—	3	3			
16.5-17.0	—	10	—	2	2	—	—	—	—	12	12	—	7	9	—	8	8			
17.0-17.5	—	8	—	3	3	—	—	—	—	4	4	—	6	8	—	3	3			
17.5-18.0	—	4	—	1	1	—	—	—	—	2	2	—	4	6	—	4	4			
18.0-18.5	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	4	4			
18.5-19.0	—	4	—	—	—	—	—	—	—	—	—	—	1	1	—	2	2			
19.0-19.5	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
19.5-20.0	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
Total	11	89	16	55	71	2	1	3	19	81	100	37	63	100	13	48	61			
Percentage	11	89	22.5	77.5	—	66.7	33.3	—	19	81	—	37	63	—	21.3	78.7	—			
Av. length, mm.	12.89	16.2	12.75	14.69	—	13.0	14.75	—	13.5	15.52	—	13.06	15.27	—	13.4	15.67	—			
Gen. av., mm.	15.84		14.25		13.58		15.13		14.45		15.18		15.18		15.18		15.18			
Total in sample	344		78		3		332		368		61		61		61		61			

Station Date	...	WS 308 8. x. 28	WS 309 8. x. 28			WS 310 8. x. 28			WS 311 10. viii. 28		WS 468 9-10. xi. 29		WS 474 13. xi. 29			WS 476 14. xi. 29			
Length mm.		Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
		9'5-10'0 10'0-10'5 10'5-11'0 11'0-11'5 11'5-12'0 12'0-12'5 12'5-13'0 13'0-13'5 13'5-14'0 14'0-14'5 14'5-15'0 15'0-15'5 15'5-16'0 16'0-16'5 16'5-17'0 17'0-17'5 17'5-18'0 18'0-18'5 18'5-19'0	— — 1 — — 1 1 2 3 — — — — — — — — — — —	— — 1 — — 1 1 1 1 1 1 — — — — — — — — —	— — 1 — — — — 1 1 1 1 — — — — — — — — —	1 1 2 3 4 5 6 1 — — — — — — — — — — —	— — — — 4 1 3 4 7 6 3 3 1 — — 1 — — — —	1 1 2 3 4 9 4 4 6 3 3 1 — — 1 — — — —	— — 1 — — — — 1 — — — — — — — — — — — —	— —	— —	— —	— —	— —	— —	— —	— — — — — — — — — — — — — — — — — — — —	— — — — — — — — — — — — — — — — — — — —	— — — — — — — — — — — — — — — — — — — —
Total	Percentage	2 20 11'50	8 80 13'63	10 — —	1 50 10'75	23 41'1 11'88	33 58'9 14'3	56 — —	1 100 18'75	1 — —	1 100 13'75	2 66'7 12'50	1 33'3 10'25	3 — —	2 66'7 13'50	3 — —	12'42	3 13'50	—
Gen. av., mm.	Av. length, mm.	13'2			12'00			13'3			13'75			13'58			12'42		
Total in sample		12			2			57			1			3			3		

DISCOVERY REPORTS

Station Date	...	...	WS 477 14-15. xi. 29			WS 478 15. xi. 29			WS 480 16. xi. 29			WS 481 16. xi. 29			WS 482 16. xi. 29			WS 485 21. xi. 29		
Length mm.			Furcilia 6	Adolescent	Total			Total	Furcilia 6	Adolescent	Total			Total	Furcilia 6	Adolescent	Total			Total
10.5-11.0			1		1			1												
11.0-11.5																				
11.5-12.0			1		1															
12.0-12.5																				
12.5-13.0																				
13.0-13.5																				
13.5-14.0																				
14.0-14.5																				
14.5-15.0																				
15.0-15.5																				
15.5-16.0																				
16.0-16.5																				
16.5-17.0																				
17.0-17.5																				
17.5-18.0																				
18.0-18.5																				
18.5-19.0																				
19.0-19.5																				
19.5-20.0																				
20.0-20.5																				
20.5-21.0																				
21.0-21.5																				
21.5-22.0																				
22.0-22.5																				
22.5-23.0																				
Total	66.7	2	3	1	1	1	1	12	3	9	5	9	14	6	5	8	10			
Percentage	11.25	66.7	11.25	33.3	16.75	100	16.75	75	25	75	35.7	64.3	18.31	16.7	83.3	20	80			
Av. length, mm.								16.75	12.92	16.75	13.45	18.31		15.15	15.15	15.15	18.00			
Gen. av., mm.			13.25		16.75		15.79		15.79		16.57		15.33		16.85					
Total in sample			3		2		14		14		14		6		11					

Station Date	...	WS 486 21. xi. 29			WS 487 22. xi. 29			WS 488 22. xi. 29			WS 489 22. xi. 29			WS 490 22-23. xi. 29			WS 491 23. xi. 29		
		Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
10'0-10'5				—			—	1		1			—			—	1		—
10'5-11'0		1		1			—	1		1			—			—			—
11'0-11'5				—			—			2			—			—			—
11'5-12'0		1		1			—	1		1			—			—			—
12'0-12'5				—			—	7		7			—			—			—
12'5-13'0		3		3			2	8		8			2			—			—
13'0-13'5				—			—	3		3			—			—			—
13'5-14'0		1	2	3			1	2		2			—			—			—
14'0-14'5		2	3	5			1	2		2			—			—			—
14'5-15'0		2	4	6			2	3		3			—			—			—
15'0-15'5		2	8	10			3	1		1			—			—			—
15'5-16'0		1	1	2			6	1		1			—			—			—
16'0-16'5				—			9	—		—			—			—			—
16'5-17'0			11	11			11	1		1			—			—			—
17'0-17'5			11	11			16	1		1			—			—			—
17'5-18'0			8	8			9	—		—			—			—			—
18'0-18'5			6	6			7	—		—			—			—			—
18'5-19'0			6	6			7	—		—			—			—			—
19'0-19'5			1	1			7	—		—			—			—			—
19'5-20'0			5	5			4	—		—			—			—			—
20'0-20'5			4	4			5	—		—			—			—			—
20'5-21'0			3	3			2	—		—			—			—			—
21'0-21'5			2	2			1	—		—			—			—			—
21'5-22'0			—	—			1	—		—			—			—			—
22'0-22'5			1	1			1	—		—			—			—			—
22'5-23'0			2	2			—	—		—			—			—			—
23'0-23'5			1	1			—	—		—			—			—			—
23'5-24'0			2	2			—	—		—			—			—			—
24'0-24'5			1	1			—	—		—			—			—			—
24'5-25'0			—	—			—	—		—			—			—			—
25'0-25'5			—	—			—	—		—			—			—			—
25'5-26'0			1	1			—	—		—			—			—			—
26'0-26'5			1	1			—	—		—			—			—			—
26'5-27'0			—	—			—	—		—			—			—			—
27'0-27'5			—	—			—	—		—			—			—			—
27'5-28'0			—	—			—	—		—			—			—			—
28'0-28'5			1	1			—	—		—			—			—			—
Total		13	87	100	7	93	100	30	10	40	4	2	6	1	1	1	1	2	3
Percentage		13	87	—	7	93	—	75	25	—	66·7	33·3	—	100	—	—	33·3	66·7	—
Av. length, mm.		13·75	17·86	—	14·04	17·67	—	12·85	17·3	—	13·38	15·50	—	12·25	—	—	10·75	17·50	—
Gen. av., mm.		17·33			17·42			13·96			14·08			12·25			15·25		
Total in sample		120			1424			45			15			1			3		

Station Date	...	WS 496 30. xii. 29	WS 497 1. i. 30		WS 498 2-3. i. 30		WS 499 3. i. 30			WS 501 3. i. 30		WS 508 10. ii. 30		WS 538 26. i. 31		WS 542 28. i. 31		WS 560 9. ii. 31	
Length mm.	Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total
13.0-13.5							1		1										
13.5-14.0																			
14.0-14.5																			
14.5-15.0																			
15.0-15.5																			
15.5-16.0	1	1	1																
16.0-16.5																			
16.5-17.0		2	2																
17.0-17.5		2	2				1	1	1										
17.5-18.0		2	2																
18.0-18.5		2	2																
18.5-19.0		2	2																
19.0-19.5		2	2																
19.5-20.0		3	3				1	1	1										
20.0-20.5		3	3																
20.5-21.0		3	3																
21.0-21.5		2	2																
21.5-22.0		2	2																
22.0-22.5		2	2																
22.5-23.0		2	2																
23.0-23.5																			
23.5-24.0																			
24.0-24.5																			
24.5-25.0																			
25.0-25.5																			
25.5-26.0																			
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29.0-29.5																			
29.5-30.0																			
30.0-30.5																			
30.5-31.0																			
31.0-31.5																			
31.5-32.0																			
32.0-32.5																			
32.5-33.0																			
33.0-33.5																			
33.5-34.0																			
34.0-34.5																			
34.5-35.0																			
35.0-35.5																			
35.5-36.0																			
Total	1	19	20	53	53	2	2	6	7	1	1	1	1	86	86	100	100	8	8
Percentage	5	95	—	100	—	100	—	85.7	—	100	—	100	—	100	—	100	—	100	—
Av. length, mm.	15.75	19.65	—	22.51	—	20.75	—	13.25	21.58	20.25	—	25.25	—	29.0	—	24.40	—	23.44	—
Gen. av., mm.		19.48		22.51		20.75		20.39		20.25		25.25		29.01		24.40		23.44	
Total in sample		21		54		3		10		1		1		5160		5522		8	

Station Date	...	453 16-17. x. 30			454 17. x. 30			455 18. x. 30			459 19. x. 30			460 20. x. 30			462 23. x. 30		
		Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
9.5-10.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.0-10.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.5-11.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.0-11.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.5-12.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12.0-12.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12.5-13.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13.0-13.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13.5-14.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14.0-14.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14.5-15.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15.0-15.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15.5-16.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16.0-16.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16.5-17.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17.0-17.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17.5-18.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18.0-18.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18.5-19.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19.0-19.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19.5-20.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20.0-20.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20.5-21.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total		4	46	50	7	93	100	13	87	100	11	89	100	6	39	45	4	96	100
Percentage		8	92	—	7	93	—	13	87	—	11	89	—	14.5	85.5	—	4	96	—
Av. length, mm.		13.25	15.43	—	12.32	16.35	—	12.90	15.79	—	12.70	15.32	—	2.0	15.21	—	12.75	15.27	—
Gen. av., mm.		15.26			16.06			15.41			15.03			14.78			15.17		
Total in sample		870			210			6600			1036			47			490		

DISCOVERY REPORTS

Station Date	...	463 25. x. 30	464 26. x. 30			465 26. x. 30			466 27. x. 30		467 28. x. 30		469 29. x. 30		470 30. x. 30			
Length mm.		Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total		
9'0- 9'5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
9'5-10'0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
10'0-10'5		1	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
10'5-11'0		1	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
11'0-11'5		1	—	1	1	1	1	7	—	8	3	—	—	1	—	—		
11'5-12'0		—	—	3	3	2	2	10	—	6	5	—	—	2	—	—		
12'0-12'5		1	—	2	2	—	—	3	—	4	2	—	—	2	—	—		
12'5-13'0		1	—	3	3	1	4	3	—	7	8	—	—	2	—	—		
13'0-13'5		—	1	3	3	2	7	5	—	6	5	—	—	1	—	—		
13'5-14'0		—	2	4	5	4	8	3	—	8	4	—	—	—	—	—		
14'0-14'5		—	—	9	13	6	5	2	—	3	1	—	—	—	—	—		
14'5-15'0		—	8	9	9	5	5	1	—	1	7	—	—	—	—	—		
15'0-15'5		—	7	7	8	4	4	—	—	—	11	—	—	—	1	—		
15'5-16'0		—	4	12	10	2	2	—	—	3	7	—	—	—	2	—		
16'0-16'5		—	6	9	12	2	2	—	—	4	12	—	—	—	—	—		
16'5-17'0		—	5	4	4	1	1	—	—	—	7	—	—	—	—	—		
17'0-17'5		—	4	6	6	2	2	—	—	—	12	—	—	—	—	—		
17'5-18'0		—	2	4	5	2	2	—	—	—	5	—	—	—	—	—		
18'0-18'5		—	2	2	3	1	1	—	—	—	2	—	—	—	—	—		
18'5-19'0		—	—	—	3	—	—	—	—	—	—	—	—	—	—	—		
19'0-19'5		—	1	1	3	—	—	—	—	—	—	—	—	—	—	—		
19'5-20'0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
20'0-20'5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
20'5-21'0		—	—	1	1	1	1	—	—	—	—	—	—	—	—	—		
21'0-21'5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
21'5-22'0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
22'0-22'5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
Total		5	43	48	22	81	103	19	33	52	3	48	97	34	76	110		
Percentage		10	90	—	21	79	—	36'5	63'5	—	100	49'5	—	30'9	69'1	—		
Av. length, mm.		11'45	15'88	—	13'31	16'28	—	12'85	15'26	—	16'08	15'75	—	12'07	16'05	—		
Gen. av., mm.		15'42			15'65			16'08			13'57			14'82			12'30	
Total in sample		58			6000			60			101			110			18	

Station Date	...	471 1. xi. 30			472 1. xi. 30			475 12. xi. 30			477 13. xi. 30			480 13. xi. 30			481 13. xi. 30			482 14. xi. 30		
		Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Total	Adolescent	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
9.5-10.0		1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.0-10.5		3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.5-11.0		2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.0-11.5		6	1	7	1	—	1	—	1	—	1	—	1	—	—	—	1	—	—	1	—	1
11.5-12.0		4	2	6	5	1	6	2	2	—	1	—	1	—	—	—	2	—	—	—	—	—
12.0-12.5		8	4	12	5	5	10	—	5	—	1	—	6	—	—	—	3	—	—	—	—	—
12.5-13.0		6	10	16	7	5	12	—	12	—	—	—	16	—	—	—	3	—	—	—	—	—
13.0-13.5		—	16	16	7	9	16	—	1	—	—	—	7	2	—	2	3	—	—	—	—	—
13.5-14.0		—	9	9	7	12	19	—	—	—	—	—	19	—	—	3	—	—	—	—	—	—
14.0-14.5		—	4	4	3	7	10	—	—	—	1	—	7	—	—	3	—	—	—	—	—	—
14.5-15.0		—	6	6	1	10	11	—	—	—	—	—	11	—	—	3	—	—	—	1	—	1
15.0-15.5		—	4	4	1	8	9	—	—	—	—	—	9	—	—	2	—	—	—	—	—	—
15.5-16.0		—	3	3	—	4	4	—	—	—	—	—	4	—	1	1	—	—	—	—	—	—
16.0-16.5		—	4	4	—	3	3	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—
16.5-17.0		—	2	2	—	3	3	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
17.0-17.5		—	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17.5-18.0		—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18.0-18.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18.5-19.0		—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19.0-19.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19.5-20.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20.0-20.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20.5-21.0		—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
21.0-21.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21.5-22.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total		30	70	100	38	62	100	—	2	6	4	2	6	2	1	3	25	75	100	2	1	3
Percentage		30	70	—	38	62	—	100	—	—	66.7	33.3	—	66.7	33.3	—	25	75	—	66.7	33.3	—
Av. length, mm.		11.70	14.11	—	12.97	14.38	—	11.75	—	—	12.50	18.50	—	13.25	15.75	—	13.15	16.58	—	13.0	19.25	—
Gen. av., mm.		13.39			13.85			11.75			14.50			14.08			15.72			15.08		
Total in sample		6410			520			2			6			3			103			3		

DISCOVERY REPORTS

Station Date	...	...	483 14. xi. 30			484 16. xi. 30			485 16. xi. 30			486 16. xi. 30			487 16. xi. 30			488 17. xi. 30			
Length mm.			Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	
9.5-10.0			—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	1	—	—
10.0-10.5			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
10.5-11.0			—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	1	—	—
11.0-11.5		1	1	—	1	1	1	2	—	—	—	—	—	—	—	—	—	2	—	—	
11.5-12.0		2	2	—	2	2	1	3	—	—	—	—	—	—	—	—	—	3	—	—	
12.0-12.5		3	3	—	3	3	1	4	—	—	2	2	—	—	3	—	—	4	—	—	
12.5-13.0		4	4	—	4	4	3	6	—	—	1	1	—	—	3	—	—	5	—	—	
13.0-13.5		11	11	—	11	11	4	3	—	—	3	3	—	—	11	—	—	3	—	—	
13.5-14.0		7	7	—	7	7	4	4	—	—	1	1	—	—	8	—	—	3	—	—	
14.0-14.5		3	3	—	3	3	2	3	—	—	2	2	—	—	5	—	—	5	—	—	
14.5-15.0		8	8	—	8	8	2	3	—	—	1	1	—	—	5	—	—	3	—	—	
15.0-15.5		9	9	—	9	9	3	3	—	—	2	2	—	—	6	—	—	2	—	—	
15.5-16.0		10	10	—	10	10	6	6	—	—	2	2	—	—	5	—	—	7	—	—	
16.0-16.5		5	5	—	5	5	6	6	—	—	2	2	—	—	1	—	—	—	—	—	
16.5-17.0		7	7	—	7	7	6	6	—	—	2	2	—	—	2	—	—	—	—	—	
17.0-17.5		11	11	—	11	11	4	4	—	—	1	1	—	—	1	—	—	—	—	—	
17.5-18.0		9	9	—	9	9	6	6	—	—	2	2	—	—	—	—	—	—	—	—	
18.0-18.5		5	5	—	5	5	11	11	—	—	5	5	—	—	—	—	—	—	—	—	
18.5-19.0		1	1	—	1	1	10	10	—	—	1	1	—	—	—	—	—	—	—	—	
19.0-19.5		5	5	—	5	5	7	7	—	—	—	—	—	—	—	—	—	—	—	—	
19.5-20.0		2	2	—	2	2	5	5	—	—	1	1	—	—	—	—	—	—	—	—	
20.0-20.5		1	1	—	1	1	5	5	—	—	—	—	—	—	—	—	—	—	—	—	
20.5-21.0		2	2	—	2	2	—	—	—	—	2	—	—	—	—	—	—	—	—	—	
21.0-21.5		1	1	—	1	1	2	2	—	—	—	—	—	—	—	—	—	—	—	—	
21.5-22.0		—	—	—	—	—	2	2	—	—	1	—	—	—	—	—	—	—	—	—	
22.0-22.5		1	1	—	1	1	1	1	—	—	1	—	—	—	—	—	—	—	—	—	
22.5-23.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Total		19	81	100		9	86	95	1	19	20	5	7	12	23	77	100	27	48	75	
Percentage		19	81	—		9.5	90.5	—	5	95	—	42	58	—	23	77	—	36	64	—	
Av. length, mm.		13.43	16.12	—		12.31	16.98	—	12.75	17.38	—	12.65	16.11	—	13.49	16.61	—	13.25	16.76	—	
Gen. av., mm.		15.71				16.53			17.15			14.66			15.90			15.5			
Total in sample		25,800				46,560			100			19			290			78			

Station Date	...	489 17. xi. 30			490 17. xi. 30			491 17. xi. 30			492 18. xi. 30			493 18-19. xi. 30		
		Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total	Furcilia 6	Adolescent	Total
11'0-11'5		1	—	1	—	—	—	5	—	5	1	—	1	—	—	—
11'5-12'0		—	—	—	—	—	—	2	—	2	—	—	—	—	—	—
12'0-12'5		—	—	—	—	—	—	4	—	4	—	—	—	—	—	—
12'5-13'0		1	—	1	—	—	—	6	—	6	2	—	2	1	—	1
13'0-13'5		—	—	—	—	—	—	9	—	9	3	—	3	—	—	—
13'5-14'0		2	1	3	—	—	—	2	3	5	2	—	2	—	—	—
14'0-14'5		—	—	—	—	—	—	5	5	10	2	—	2	—	—	—
14'5-15'0		1	1	2	1	—	—	2	5	7	2	—	2	—	—	—
15'0-15'5		—	—	—	—	—	—	2	8	10	1	—	1	—	—	—
15'5-16'0		—	2	2	—	—	—	2	3	5	1	—	1	—	—	—
16'0-16'5		—	—	—	—	—	—	1	8	9	—	—	—	—	1	—
16'5-17'0		—	—	—	—	—	—	—	2	2	—	—	—	—	—	—
17'0-17'5		—	—	—	—	—	—	—	6	6	—	—	—	—	—	—
17'5-18'0		—	—	—	—	—	—	—	3	3	—	—	—	—	—	—
18'0-18'5		—	—	—	—	—	—	—	7	7	—	—	—	—	—	—
18'5-19'0		—	—	—	—	—	—	—	4	4	—	—	—	—	—	—
19'0-19'5		—	—	—	—	—	—	—	7	7	—	—	—	—	—	—
19'5-20'0		—	1	1	—	—	—	—	5	5	—	—	—	—	—	—
20'0-20'5		—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
20'5-21'0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21'0-21'5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21'5-22'0		—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
22'0-22'5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22'5-23'0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23'0-23'5		—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
23'5-24'0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total		5	5	10	1	3	4	31	69	100	15	85	100	1	15	16
Percentage		50	50	—	25	75	—	31	69	—	15	85	—	6	94	—
Av. length, mm.		13'25	15'65	—	14'25	16'58	—	13'05	16'56	—	13'32	17'31	—	12'25	19'12	—
Gen. av., mm.		14'45			16'00			15'48			16'71			18'69		
Total in sample		16			4			226			31,200			49		

Station Date	...	...	494 19. xi. 30			495 19. xi. 30			496 19. xi. 30			498 21. xi. 30			499 21. xi. 30		500 21. xi. 30		
Length mm.	494 19. xi. 30		495 19. xi. 30		Total	496 19. xi. 30		Total	498 21. xi. 30		Total	499 21. xi. 30		Total	500 21. xi. 30		Total		
	Furcilia 6	Adolescent	Furcilia 6	Adolescent		Furcilia 6	Adolescent		Furcilia 6	Adolescent		Furcilia 6	Adolescent						
12.0-12.5	1	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—		
12.5-13.0	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
13.0-13.5	—	1	—	—	—	—	—	—	—	—	—	—	—	—	2	2	4		
13.5-14.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
14.0-14.5	1	—	—	—	—	1	—	—	1	—	1	—	—	—	3	4	7		
14.5-15.0	3	2	—	2	3	1	—	—	—	—	—	—	—	—	2	5	7		
15.0-15.5	5	1	—	—	6	—	—	—	—	—	—	—	—	—	6	6	10		
15.5-16.0	1	5	—	—	6	—	—	—	—	—	—	—	—	—	3	7	10		
16.0-16.5	3	12	—	—	15	—	—	—	—	—	—	—	—	—	—	6	8		
16.5-17.0	—	11	—	1	11	—	—	—	—	—	—	—	—	—	—	7	7		
17.0-17.5	—	8	—	1	9	—	—	—	—	—	—	2	—	2	—	7	7		
17.5-18.0	—	10	—	—	10	—	—	—	—	—	—	—	—	—	—	8	8		
18.0-18.5	—	9	—	—	9	—	—	—	—	—	—	—	—	—	—	7	7		
18.5-19.0	—	3	—	1	4	—	—	—	—	—	—	—	—	—	—	4	4		
19.0-19.5	—	3	—	1	4	—	—	—	—	—	—	—	—	—	—	3	3		
19.5-20.0	—	6	—	2	8	—	—	—	—	—	—	—	—	—	—	7	7		
20.0-20.5	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	5	5		
20.5-21.0	—	3	—	—	3	—	—	—	—	—	—	—	—	—	—	3	3		
21.0-21.5	—	2	—	1	3	—	—	—	—	—	—	—	—	—	—	1	1		
21.5-22.0	—	2	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—		
22.0-22.5	—	2	—	—	2	—	—	—	—	—	—	—	—	—	—	2	2		
22.5-23.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3		
23.0-23.5	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	1	1		
23.5-24.0	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	1	1		
24.0-24.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
24.5-25.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
25.0-25.5	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—		
25.5-26.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
26.0-26.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
26.5-27.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1		
Total	16	84	100	9	10	2	6	8	2	2	4	2	2	2	12	88	100		
Percentage	16	84	—	90	—	25	75	—	50	50	—	100	—	—	12	88	—		
Av. length, mm.	14.81	18.01	—	18.03	—	14.25	16.17	—	13.25	18.75	—	17.75	—	—	14.46	17.45	—		
Gen. av., mm.	17.50		17.70		15.69		16.00		17.75		17.09								
Total in sample	39,600		28		9		4		2		125								

Station Date	...	502 22. xi. 30			503 23. xi. 30		506 23. xi. 30		507 23. xi. 30			508 24. xi. 30		509 24. xi. 30			511 25. xi. 30		
Length mm.	...	Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total	
11.5-12.0		—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	
12.0-12.5		—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	
12.5-13.0		—	—	—	1	1	—	—	4	—	4	—	—	—	—	—	—	—	
13.0-13.5		—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	
13.5-14.0		—	2	2	—	—	1	1	1	—	1	—	—	—	—	—	—	—	
14.0-14.5		2	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	
14.5-15.0		1	2	2	2	2	2	2	2	—	8	—	—	—	—	—	—	—	
15.0-15.5		3	3	3	—	—	—	—	1	—	7	—	—	—	—	—	—	—	
15.5-16.0		—	4	4	1	1	—	—	2	—	9	—	—	—	—	—	—	—	
16.0-16.5		3	3	3	4	4	—	—	—	—	10	—	—	—	—	—	—	—	
16.5-17.0		3	9	12	7	7	—	—	—	—	6	—	—	—	—	—	—	—	
17.0-17.5		—	2	2	7	7	—	—	—	—	7	—	—	—	—	—	—	—	
17.5-18.0		—	3	3	6	6	—	—	—	—	6	—	—	—	—	—	—	—	
18.0-18.5		—	3	3	4	4	—	—	—	—	5	—	—	—	—	—	—	—	
18.5-19.0		—	5	5	4	4	—	—	—	—	10	—	—	—	—	—	—	2	
19.0-19.5		—	2	2	3	3	1	1	—	—	3	—	—	—	—	—	—	2	
19.5-20.0		—	6	6	4	4	1	1	—	—	8	—	—	—	—	—	—	2	
20.0-20.5		—	2	2	1	1	1	1	—	—	2	—	—	—	—	—	—	4	
20.5-21.0		—	6	6	2	2	—	—	—	—	3	—	—	—	—	—	—	2	
21.0-21.5		—	1	1	—	—	—	—	—	—	2	—	—	—	—	—	—	4	
21.5-22.0		—	3	3	2	2	—	—	—	—	3	—	—	—	—	—	—	2	
22.0-22.5		—	1	1	1	1	—	—	—	—	1	—	—	—	—	—	—	4	
22.5-23.0		—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	2	
23.0-23.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	
23.5-24.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	
24.0-24.5		—	1	1	—	—	—	—	—	—	1	—	—	—	—	—	—	4	
24.5-25.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	
25.0-25.5		—	1	1	—	—	—	—	—	—	1	—	—	—	—	—	—	1	
25.5-26.0		—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1	
Total Percentage Av. length, mm.		9 13 15.64	58 87 18.59	67 — —	50 100 18.05	50 — —	6 100 17.08	6 — —	14 14 13.03	86 86 17.75	100 — —	1 100 21.25	1 — —	1 20 15.75	4 80 17.50	5 — —	32 100 20.92	32 — —	
Gen. av., mm.		18.19			18.05		17.08		17.19			21.25		17.15			20.92		
Total in sample		67			119		6		2100			1		6			32		

Station Date	...	512 25. xi. 30		513 25. xi. 30		514 26. xi. 30			516 26. xi. 30		517 26. xi. 30		518 27. xi. 30			519 27. xi. 30	
Length mm.		Total		Total		Furcilia 6	Adolescent	Total	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total
		Adolescent	Total	Adolescent	Total												
14.5-15.0		—	—	—	—	—	—	—	—	—	—	—	1	1	2	—	—
15.0-15.5		—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
15.5-16.0		—	—	—	1	—	—	—	—	—	—	—	1	1	1	—	—
16.0-16.5		—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—
16.5-17.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17.0-17.5		—	—	—	—	1	—	1	—	—	—	—	1	—	1	—	—
17.5-18.0		—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
18.0-18.5		—	—	—	—	—	—	1	—	2	2	2	—	5	5	5	—
18.5-19.0		—	—	—	1	—	—	—	—	3	3	3	—	5	5	—	—
19.0-19.5		—	—	—	—	—	—	—	1	5	2	2	—	2	3	—	1
19.5-20.0	1	—	—	—	—	—	—	1	—	6	6	6	—	3	3	—	—
20.0-20.5	—	—	—	—	—	—	—	1	—	2	2	2	—	2	2	—	—
20.5-21.0	—	—	—	—	—	—	—	2	—	6	6	6	—	2	6	—	—
21.0-21.5	—	—	—	—	—	—	—	1	—	4	4	4	—	6	6	—	1
21.5-22.0	—	—	—	—	—	—	—	—	—	7	7	7	—	3	3	—	1
22.0-22.5	—	—	—	—	—	—	—	—	—	8	8	8	—	6	6	—	—
22.5-23.0	—	—	—	—	—	—	—	—	—	10	10	10	—	5	5	—	—
23.0-23.5	—	—	—	—	—	—	—	1	—	9	9	9	—	1	1	—	—
23.5-24.0	—	—	—	—	—	1	2	2	2	10	10	10	—	3	3	—	—
24.0-24.5	—	—	—	—	—	—	1	1	1	1	1	1	—	2	2	—	—
24.5-25.0	—	—	—	—	—	—	1	1	1	6	6	6	—	4	4	—	—
25.0-25.5	—	—	—	—	—	—	—	—	—	9	9	9	—	3	3	—	—
25.5-26.0	—	—	—	—	—	—	—	—	—	3	3	3	—	3	3	—	—
26.0-26.5	—	—	—	—	—	—	—	—	—	5	5	5	—	1	1	—	—
26.5-27.0	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
27.0-27.5	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	—
27.5-28.0	—	—	—	—	—	—	—	—	—	4	4	4	—	1	1	—	—
28.0-28.5	—	—	—	—	—	—	—	—	1	1	1	1	—	—	—	—	—
28.5-29.0	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	—
29.0-29.5	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	—
Total Percentage Av. length, mm.		1 100 19.75	1 — —	2 100 17.25	2 — —	1 8 16.75	13 100 22.09	13 — —	100 100 22.47	100 — —	3 4 15.75	71 96 21.39	3 — —	3 100 20.58	74 — —	3 — —	20.58
Gen. av., mm.		19.75		17.25		17.67			22.09		22.47		21.16			20.58	
Total in sample		1		2		12			13		956		87			4	

Station Date	...	520 28. xi. 30		521 28. xi. 30		522 28. xi. 30		523 29. xi. 30		525 29. xi. 30		537 19. xii. 30		543 20. xii. 30			547 20. xii. 30	
		Adolescent	Total	Furcilia 6	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total	Adolescent	Total	Furcilia 6	Adolescent	Total	Adolescent	Total
14.5-15.0		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15.0-15.5		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15.5-16.0		—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—
16.0-16.5		—	—	—	—	—	—	—	—	2	2	—	—	—	—	—	—	—
16.5-17.0		—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—
17.0-17.5		—	—	—	—	1	1	1	1	1	1	1	1	—	1	1	1	1
17.5-18.0		—	—	—	—	—	—	2	2	—	—	2	2	—	—	—	—	—
18.0-18.5		—	—	—	—	—	—	3	3	—	—	—	—	—	—	—	—	—
18.5-19.0	3	—	—	—	—	1	1	4	4	—	—	—	—	—	—	—	—	—
19.0-19.5	2	—	—	—	—	—	—	4	4	1	1	—	—	—	—	—	—	—
19.5-20.0	—	—	—	—	—	—	—	9	9	—	—	1	1	—	—	—	—	—
20.0-20.5	—	—	—	—	—	—	—	5	5	1	1	8	8	—	—	—	—	—
20.5-21.0	2	—	—	—	—	—	—	15	15	—	—	10	10	—	—	—	—	—
21.0-21.5	1	—	—	—	—	—	—	4	4	—	—	7	7	—	—	—	—	—
21.5-22.0	—	—	—	—	—	—	—	8	8	—	—	12	12	—	—	—	—	—
22.0-22.5	2	—	—	—	—	—	—	4	4	1	1	16	16	—	—	—	—	—
22.5-23.0	1	—	—	—	—	—	—	10	10	1	1	10	10	—	—	—	—	—
23.0-23.5	—	—	—	—	—	—	—	4	4	—	—	6	6	—	1	1	1	1
23.5-24.0	2	—	—	—	—	—	—	9	9	—	—	5	5	—	—	—	—	—
24.0-24.5	1	—	—	—	—	—	—	4	4	—	—	4	4	—	—	—	—	—
24.5-25.0	—	—	—	—	—	—	—	6	6	—	—	6	6	—	—	—	—	—
25.0-25.5	—	—	—	—	—	—	—	2	2	—	—	—	—	—	—	—	—	—
25.5-26.0	1	—	—	—	—	—	—	4	4	—	—	2	2	—	—	—	—	—
26.0-26.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26.5-27.0	—	—	—	—	—	—	—	1	1	—	—	1	1	—	—	—	—	—
27.0-27.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
27.5-28.0	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—
28.0-28.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28.5-29.0	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—
Total	15	15	15	1	1	2	2	100	100	9	9	100	100	1	1	2	2	2
Percentage	100	100	100	100	100	100	100	100	100	100	100	100	100	50	50	100	100	100
Av. length, mm.	21.48	—	—	15.75	—	18.00	—	21.85	—	19.97	—	21.90	—	14.75	19.25	—	20.50	—
Gen. av., mm.	21.48	—	15.75	18.00	—	21.85	—	19.97	—	21.90	—	17.00	—	20.50	—	2	2	2
Total in sample	15	—	1	2	—	11,400	—	9	—	7536	—	2	—	2	—	2	2	2

[illegible]

DISCOVERY REPORTS

Time ...	0237-0300 (cont.)				0629-0652								1025-1046		1429-1449		Total larvae		
Net ... Depth, m. ...	DV 490-385		DVI 600-490		EI 75-0		E III 245-160		E IV 330-245		EV 420-330		EVI 515-420		FI 80-0			GI 95-0	
Length mm.	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent	Furcilia 6	Adolescent		Furcilia 6	Adolescent
9.5-10.0	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
10.0-10.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
10.5-11.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17
11.0-11.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	28
11.5-12.0	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	62
12.0-12.5	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	76
12.5-13.0	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	129
13.0-13.5	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	102
13.5-14.0	2	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	128
14.0-14.5	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	117
14.5-15.0	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	107
15.0-15.5	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	70
15.5-16.0	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	76
16.0-16.5	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	48
16.5-17.0	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	41
17.0-17.5	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18
17.5-18.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14
18.0-18.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8
18.5-19.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9
19.0-19.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
19.5-20.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
20.0-20.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
20.5-21.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
																			—
Total	6	31	1	9	4	15	4	4	2	4	1	—	—	—	5	7	11	39	Grand total examined = 1165
Percentage	16	84	10	90	21	79	33	67	100	100	100	—	—	—	42	58	22	78	
Av. length, mm.	12.25	14.56	12.25	15.80	11.13	15.62	11.00	14.88	12.75	12.75	—	—	—	—	12.55	13.89	12.02	14.62	
Total in sample	41		10		25		4		7		2		4		13		3584		Grand total in all nets = 17,501